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51ST CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, Part 2.

REPORT

OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE SECOND SESSION OF THE FIFTY-FIRST CONGRESS.

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O. H. ERNST, Major of ENGINEERS, U. S. A.;
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REPORT OF COLONEL GEO. H. MENDELL, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

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3. San Francisco Harbor, San Pablo and Suisun Bays, Straits of Carquinez, and mouths of Sacramento and San Joaquin rivers, California.

HARBOR-LINES.

4. Establishment of harbor-lines of San Francisco Harbor and adjacent waters.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., July 5, 1890.

GENERAL: I have the honor to inclose annual reports upon the river and harbor works under my charge.

Very respectfully, your obedient servant,

G. H. MENDELL,
Colonel Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

Q Q 1.

IMPROVEMENT OF NAPA RIVER, CALIFORNIA.

The project is to clear the river of snags and to give a channel of 75 feet width, with a depth of 4 feet.

In 1889 the snags were removed, and no complaint has since been made on this account. The bar near the steamer landing then dredged has again become troublesome by redeposit.

Car's Bend is very abrupt, and is an obstacle which can be removed by dredging a new channel through a low marshy point. Dredging about 12,000 yards will make this passage convenient to all vessels.

At present these appear to be the only respects in which navigation

needs improvement, although snags and deposits may be expected from time to time, and they need to be removed as they occur, no constructions in the bed of the stream being able to prevent their occurrence in times of freshet.

No operations were carried on during the year, and no expenditure was made.

To complete the project will require excavation of about 45,000 cubic yards of gravel, which ought to be included in one contract.

Money statement.

July 1, 1889, amount available	3,114.55
July 1, 1890, balance available	3,114.55
Amount appropriated by act of September 19, 1890	10,000.00
Amount available for fiscal year ending June 30, 1891	13,114.55
Amount (estimated) required for completion of existing project	10,100.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	10,100.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

		1884.	1889.
Merchandise received	tons	22,800	34,050
Coal received	do	5,000	7,700
Hay shipped	do	2,000	2,000
Grain shipped	do	3,000	6,300
Lumber received	do	18,333	12,862
Wine received and shipped	do	7,500	15,250
Miscellaneous freight received and shipped	do	5,936	10,500
Total		64,569	88,662
Steamers	number	2	3
Tonnage	tons	176	526
Trips by steamers	number	276	426
Schooners	gross registered tonnage	18,000	26,000

Q Q 2.

IMPROVEMENT OF OAKLAND HARBOR, CALIFORNIA.

PROJECT.

The project is intended to secure a low-water depth of about 20 feet. This depth is to be secured mainly by dredging and maintained by tidal influences, controlled by two jetties extended into San Francisco Bay, and increased by dredging in the upper basin and by introduction of waters of San Leandro Bay. The tide adds to the low-water depth 3 to 7 feet in different phases of the moon.

OPERATIONS OF THE PAST YEAR.

At the beginning of the year contracts were in force (1) for furnishing and laying stone on the jetties, (2) for dredging the tidal basin, (3) for dredging the channel between the jetties, (4) for excavating in tidal

canal 600,000 cubic yards, and (5) for dredging the channel in front of the city of Oakland.

The three first named contracts were fulfilled during the year, leaving the two last named uncompleted.

JETTIES.

This contract was fulfilled on October 23, after two extensions during the year of 75 days in all. The work during the year was 5,446⅓ tons of stone delivered and 25,197 square feet of surface laid up, of which 2,844 tons were applied to the north jetty and 2,602 tons to the south jetty. The quantity of masonry laid up during the year was for the north jetty 700 square feet, and for the south jetty 24,497 square feet. The total of material and work included in the contract is 9,400¾ tons of stone and 40,656½ square feet of surface laid up.

DREDGING TIDAL BASIN.

This contract was completed on March 24, 495,387 cubic yards having been excavated during the year and securely placed ashore.

The total amount included in the contract was 621,935 cubic yards, covering 56½ acres of tidal basin.

JETTY CHANNEL.

Dredging to the amount of 122,907 cubic yards was done during the year, the spoil being placed behind the jetties. The contract was fulfilled March 21, having been extended from October 1, 1889, giving a channel 300 feet wide and 14 feet deep at low water throughout the length of jetties to San Francisco Bay. The total amount of the contract was 239,652 cubic yards.

EXCAVATION OF TIDAL CANAL.

This contract is not yet completed, although the date set for completion is long past. The delay is to a great extent due to a long and stormy winter, which compelled suspension of operations for the months of December and January. The excavation was allowed to fill with water, which brought a further suspension of excavation during February and the greater part of March, during which interval the water was pumped out.

The amount of excavation accomplished during the year was 292,653 cubic yards. The amount remaining to be done under the requirements of the contract is 210,817 cubic yards. The total of the contract is 600,000 cubic yards.

CITY FRONT CHANNEL.

This work is to add 125 feet to the width of the present 14-foot channel, now 100 feet wide, extending along the city front.

The work was to be begun on October 1, 1889, but owing to delays in executing the jetty channel work the dredge of the contractor did not become available until March 5, 1890, which was the actual date of beginning. The contract date of completion is August 1, 1890.

The amount of the contract is estimated to be 100,000 cubic yards.

The amount done at close of the year is 38,544 cubic yards. The material is very hard, and progress is frequently interrupted by breakage of machinery. The spoil is placed behind a wooden bulkhead.

Progress has been made in studies preliminary to fixing harbor-lines. Some delay has occurred from want of agreement among riparian owners or claimants. It is hoped that adjustment of these differences may soon permit establishment of harbor-lines.

The usual annual survey of the channel was made at the close of the year.

A drawing has been made of an iron bridge on masonry piers to cross the canal at the foot of Park street, Alameda. Borings for foundations of piers were also made.

PRESENT CONDITION OF THE WORK.

In the basin there remain to be dredged about 700,000 cubic yards.

The north jetty is in length 9,203 feet. It is not expected to extend it farther. The outer end for a distance of 2,748 feet is left in a rough state and needs more stone, and also requires to be finally shaped by laying up the surfaces in dry masonry.

The south jetty is 11,863 feet in length, the outer portion for a distance of 2,465 feet being yet unfinished, and requiring stone and shaping. Experience shows thus far no tendency to formation of a bar outside the jetties. The channel maintains its depth outside the jetties. It now seems quite probable that little or no extension of the south jetty will be needed.

The channel from Oakland to the Bay of San Francisco has throughout its length a depth of 14 feet at low water, to which the tide adds twice in twenty-four hours 3 to 6 feet. The width of channel is for much the greater part of its length 300 feet. Immediately in front of the city the width varies from 100 to 225 feet, and a dredge is now widening all of it to 225 feet. It is expected that this width will be fully secured in three or four months.

The work already done on the tidal canal is less than one-sixth of the whole. About one-fourth of the whole is under contract.

FUTURE OPERATIONS.

The objects to which the next appropriation ought to be applied are to completion of the north jetty, to further widening of the channel in front of Oakland, to conclusion of dredging in basin, to continuation of the canal, and to construction of a bridge over the canal at Park street, Alameda.

The total amount appropriated for this work is $1,284,600. The amount expended to the close of the fiscal year ending June 30, 1889, was $979,247.88; the amount expended during the year ending June 30, 1800, was $189,439.81; the amount retained on contracts uncompleted is $8,936.90, and the amount covered by work to be done under these contracts is $61,780.69.

This work was under the charge of Lieutenant-Colonel Benyaurd from July 1 to August 19, 1889.

L. J. Le Conte, C. E., was assistant engineer during the whole year.

Money statement.

July 1, 1889, amount available	*$60,144.90
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	14,950.18
July 1, 1890, balance available	45,194.72
Amount appropriated by act of September 19, 1890	250,000.00
Amount available for fiscal year ending June 30, 1891	295,194.72
Amount (estimated) required for completion of existing project	991,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	500,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

The following tables, compiled by Mr. Le Conte, show the general business that passed through the jetties each year since the beginning of operations:

Years.	Traffic by steam ferries.				Traffic by vessels.		
	No.	Trips.	Passengers.	Freight.	Number.	Register.	Freight.
				Tons.		*Tons.*	*Tons.*
1874	1	600	.....	60,000	1,415	70,750	94,300
1878	3	5,400	216,240	129,000	1,085	109,125	211,627
1881	3	8,800	858,352	1,051,788	1,129	129,714	173,448
1882	3	9,400	892,210	1,150,379	1,004	144,004	257,614
1883	3	8,000	974,901	1,142,918	1,031	143,886	215,829
1884	3	8,000	1,553,769	1,202,230	1,156	163,553	255,738
1885	3	6,000	444,142	1,439,134	1,326	200,226	305,437
1886	3	6,000	318,402	1,487,924	1,673	188,974	264,050
1887	3	8,520	210,423	1,654,451	1,224	130,913	231,660
1888	3	8,520	200,000	1,876,635	1,384	162,957	295,932
1889	3	8,600	100,000	1,755,247	1,745	185,358	338,123

The following comparative grand totals of traffic through the jetties show the increase in fifteen years:

Traffic.	1874 (before improvement).		1889 (after improvement).	
	Passengers.	Freight.	Passengers.	Freight.
		Tons.		*Tons.*
By ferry	None.	60,000	100,000	1,755,247
By vessels	None.	94,300	.....	338,123
Total	.....	154,300	100,000	2,093,370

The nearest port of entry is that of San Francisco, distant 3 miles from the mouth of the jetties.

Customs duties, 1890 ..... $8,355,552

*Erroneously stated in annual report for 1889 as $51,144.90.

Q Q 3.

SURVEY OF SAN FRANCISCO HARBOR, SAN PABLO AND SUISUN BAYS, STRAITS OF CARQUINEZ, AND MOUTHS OF SAN JOAQUIN AND SACRAMENTO RIVERS.

The only operations carried on during the past year were in preparation of maps suitable for designation of harbor-lines.

The lines of San Francisco Harbor and Mission Rock Front were laid down, and subsequently they were approved by the War Department. A copy was furnished to the Board of State Harbor Commissioners. The maps for the fronts of Port Costa, Benicia, and Vallejo are nearly completed. The lines to be recommended are determined upon and only await the completion of maps.

The survey made in 1887–'88 covered 110½ square miles of the bay, taking in the city fronts of San Francisco, Oakland, and portions lying both to the north and south, in all 14′ in latitude. To complete the entrance chart out to 10 fathoms, about 100 square miles need to be surveyed, the estimated cost of which, including maps, is $16,000.

Money statement.

July 1889, amount available	$1,446.51
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	318.12
July 1, 1890, balance available	1,128.39
Amount (estimated) required for completion of existing project	16,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	16,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

Q Q 4.

ESTABLISHMENT OF HARBOR-LINES OF SAN FRANCISCO HARBOR AND ADJACENT WATERS.

(For authority of the Secretary of War to establish the harbor-lines of San Francisco and adjacent waters, see Appendix R R 5, page 2904.)

a. HARBOR-LINES FOR THE WATER-FRONT OF THE CITY OF SAN FRANCISCO, AND AT MISSION ROCK, BAY OF SAN FRANCISCO.

SAN FRANCISCO, CAL., *March* 11, 1890.

GENERAL: The Board of Engineer Officers constituted by paragraph 2 of Special Orders, No. 51, from Headquarters Corps of Engineers, Washington, D. C., October 11, 1888, to establish the harbor-lines of San Francisco Harbor and adjacent waters, has the honor to submit the following report on the lines for the water-front of the city of San Francisco and at Mission Rock, Bay of San Francisco.

The Board held consultations with the Board of State Harbor Commissioners, and received from that body the maps of the city-front, showing the harbor-lines adopted under an act of the legislature of the State of California, approved February 28, 1876. Consultations were held with the officers of the company owning the wharves at Mission Rock. The Board made an examination of these wharves and the de-

posits on and around the rock, and also caused a survey of the same to be made.

On the map herewith the bulkhead and pier-head lines for the city-front of San Francisco, as established by the Board, are shown. They are substantially the same as those adopted by the Board of State Harbor Commissioners under the act of the legislature above mentioned, with the exception that a change has been made in the pier-head line in the vicinity of Mission Rock. Along this stretch this line has been drawn in closer to the bulkhead line, as hereinafter described, in order to prevent as little interference as possible with the tidal currents.

The following is a description of the lines as established:

BULKHEAD LINE.

A line parallel to and distant two hundred feet outwardly or seaward from a line described as follows: Beginning at a point in the prolongation northerly of the eastern boundary line of the Presidio Reservation, distant two hundred feet northerly from the northerly line of Lewis street, said distance of two hundred feet being measured at right angles to the line of Lewis street; thence in a straight line and parallel to Lewis street to the westerly line of Webster street; thence in a straight line drawn to the intersection of the westerly line of Polk street with the southerly line of Lewis street to where the easterly line of Laguna street prolonged intersects said line. The line is then omitted in front of the Government Reservation at Point San José. It commences again at Van Ness avenue, 200 feet outward and parallel to the following described line: Starting at the intersection of the westerly line of Van Ness avenue with the southerly side of Lewis street; thence to the intersection of the westerly line of Polk street with the southerly line of Lewis street; thence in a straight line to the intersection of the westerly line of Powell street with the southerly line of Jefferson street; thence in a straight line to the intersection of the westerly line of Dupont street with the southerly line of Beach street; thence in a straight line to the intersection of the southerly line of North Point street with the westerly line of Kearney street; thence in a straight line to the intersection of the northerly line of Francisco street with the easterly line of Montgomery street (said streets beinge stimated at 150 feet in width); thence in a straight line to the intersection of the southerly line of Lombard street with the westerly line of Battery street; thence in a straight line to the intersection of the southerly line of Filbert street with the westerly line of Front street; thence in a straight line to a point in the southerly line of Pacific street, distant 75 $\frac{6}{12}$ feet easterly from the easterly line of Drumm street; thence in a direct course toward the intersection of the northerly line of Mission street with the westerly line of East street, to a point 283 feet, measured on said course northerly from the northerly line of Mission street; thence in a straight line to the intersection of the southerly line of Folsom street (as the same is laid out west of Stuart street) with the westerly line of East street; thence in a straight line passing through the point formed by the intersection of the northerly line of Harrison with the westerly line of Stuart street to a point 137½ feet southerly from the southerly line of Harrison street (said distance of 137½ feet to be measured at right angles to Harrison street); thence in a straight line to the intersection of the westerly line of Spear street with the northerly line of Bryant street; thence in a straight line to the intersection of the westerly line of First street with the northerly line of Townsend street; thence southerly in a straight line 3,300 feet to a point 640 feet easterly from the westerly line of Kentucky street (said distance of 640 feet to be measured at right angles to Kentucky street); thence in a straight line to the intersection of the westerly line of Water-front street with the easterly line of Wyoming street; thence along the westerly line of Water-front street, and said westerly line prolonged to its intersection with a curve of 1,326.06 feet radius described from the intersection of the southerly line of A street with the easterly line of Sixth avenue as a center; thence southerly along said curve to a point in the prolongation northerly of the westerly line of Water-front street (as the same is laid out south of Eleventh avenue); and thence along the westerly line of said Water-front street to the boundary-line between the city and county of San Francisco and the county of San Mateo.

PIER-HEAD LINE.

Starting from a point on the prolongation of the easterly line of the Presidio reservation and 600 feet distant, a line is drawn parallel with said bulkhead line until it intersects the northerly side of Brannan street, prolonged (omitting the stretch in front of the Government reservation at Point San José); thence in a straight line to

a point on a line drawn from the north corner of Berry and East streets, and parallel with Second, and 770 feet distant from said corner; thence in a curve of 1° to a point on the prolongation of the southerly line of Alameda street; thence in a straight line to a point on prolongation of the northerly line of Butte street and 600 feet distant from the bulkhead line; thence parallel with said bulkhead line to the southerly limit of the city.

The straight portions of the pier-head line are connected by arcs of circles with radii of 600 feet.

LINES AT MISSION ROCK.

The California Dry Dock Company, under an act of the legislature of the State of California approved April 4, 1870, providing for the sale of certain submerged lands in the city and county of San Francisco, claim title to Mission Rock and surrounding area of the bay to the extent of 800 feet square. The company has made deposits on and around the rock, so that from a small beginning there is now an area of 3.9 acres inclosed within the low-water contour. Wharves have been constructed over a portion of the claim, the bounding lines of which are shown on the map in red, the dotted line representing the boundary of the claim.

The Board is of the opinion that the company should cease depositing any more material in the bay, and has therefore established the line now representing the boundary of the deposits at low water (shown on the map in black) as the line beyond which no deposits shall hereafter be made.

It is not considered advisable to allow the wharf to be projected on the easterly and westerly sides beyond the line now representing the faces of the wharf as at present constructed. There is no objection to allowing the extension of the easterly and westerly faces to the northwesterly and southeasterly boundary-lines of the claim as shown in blue. The lines as thus laid out are established as the wharf-lines at Mission Rock, and are described as follows:

Beginning at a point on the northwest boundary-line of the claim 146 feet from the north corner of said claim; thence S. 40° 27′ E. 512.04 feet; thence S. 60° 32′ E. 26 feet; thence S. 7° 41′ W. to the southeast boundary of the claim; thence S. 45° W. 186 feet, more or less; thence N. 44° 42′ W. 380.42 feet, more or less; thence N. 17° 34′ W. to the northwesterly boundary of the claim; thence N. 45° E. to the point of beginning.

The position of Mission Rock and wharf-lines with reference to the bulkhead and pier-head lines of San Francisco is shown on the map of the harbor lines of that city.

G. H. MENDELL,
Colonel, Corps of Engineers.
W. H. H. BENYAURD,
Lieut. Col., Corps of Engineers.
W. H. HEUER,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
March 22, 1890.

Respectfully submitted to the Secretary of War.

The Harbor Line Board for San Francisco Harbor and adjacent waters, California, constituted by paragraph 2 of Special Orders No. 51,

Headquarters Corps of Engineers, October 11, 1888, recommends for approval of the Secretary of War bulkhead and pier-head lines for the city front of San Francisco and around Mission Rock, San Francisco Harbor, described in the within report and delineated upon the accompanying charts.

It is recommended that the lines selected be approved and that the Secretary place his approval both upon the report and the tracings submitted.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

[Second indorsement.]

WAR DEPARTMENT, *March* 24, 1890.

Approved.

REDFIELD PROCTOR,
Secretary of War.

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b. HARBOR-LINES OF PORT COSTA AND MARTINEZ ON THE SOUTH SHORE OF CARQUINEZ STRAIT, AND BENICIA ON THE NORTH SHORE, AND EAST SHORE OF MARE ISLAND STRAIT, ALONG THE FRONTS OF NORTH VALLEJO, VALLEJO, AND SOUTH VALLEJO, AND FRONT OF MARE ISLAND NAVY-YARD ON MARE ISLAND STRAIT.

SAN FRANCISCO, CAL., *July* 22, 1890.

GENERAL: The Board of Engineer Officers constituted by paragraph 3, Special Orders No. 51, from Headquarters Corps of Engineers, Washington, D. C., October 11, 1888, to establish harbor-lines from San Francisco Harbor and adjacent waters, has the honor to recommend for adoption the following-described lines along the fronts of Port Costa and Martinez on the south shore of Carquinez Strait and Benicia on the north shore, and along the fronts of North Vallejo, Vallejo, and South Vallejo and Mare Island navy-yard on Mare Island Strait.

PORT COSTA AND MARTINEZ, SOUTH SHORE, STRAIT OF CARQUINEZ.

Bulkhead line.—Beginning at a point abreast the western end of tunnel about 50 yards east of California Redwood Company's Wharf at the level of mean low tide, thence in a right line towards the brick smoke-stack of the Selby Smelting Works until low-tide level is again reached; thence along the line of low water until about abreast the middle of the Port Costa Lumber Company's Wharf; thence in a right line across the bight in a general easterly direction until low-tide level is again reached, back of the brick building known as "Starr's Mill;" thence easterly along low-tide level to a point inside of the eastern end of Grangers's Wharf; thence across the bight of low-tide level inside of the eastern end of California Wharf Company's Wharf; thence along low-tide level to a point 1 statute mile west of the Martinez Pier; thence along an easy curve as shown on the map, Peacock's survey, to a point on the Martinez Pier, 400 feet inside of its outer end; thence continuing along this curve until low-tide level is again reached about 1 mile east of this pier on the south shore of the strait, essentially as shown.

Pier-head line.—Commencing on the south shore in Contra Costa County, the line of the piers shall not extend beyond the following-described line: Starting from a point in the strait on the prolongation of the axis of the California Redwood Company's wharf, distant from the center line of the Southern Pacific Railroad Company's track 2,100 feet, where a depth of 24 feet at mean low tide is shown on Coast Survey map, scale 1 to 10000, made by Lieutenant Peacock, U. S. Navy, in 1886; thence on an easy curve essentially of 24 feet depth, drawn from this point to the outer end of the present dump nearly north of the brick smoke-stack of the Selby Smelting Works, which is 510 feet north of the center line of the Southern Pacific Railroad Company's main track; thence to the present westerly end of the Smelting Company's wharf; thence along said line of wharf to its easterly end; thence in a straight line

easterly to a point abreast the northwest corner of the Port Costa Lumber Company's wharf, and distant from the center line of the Southern Pacific Railroad Company's main track 360 feet; thence in a right line to the northwest corner of the wharf occupied by Starr & Co.'s mill; thence along the line of this wharf to its northeast end; thence in a straight line to the northwest corner of the wharf near Heald's Agricultural Works, and along said wharf to its northeast corner; thence to the northwest corner of the wharf owned by the Fort Bragg Redwood Company; thence along the north line of said wharf to its northeast corner; thence in a straight line to the northwest corner of Granger's Wharf, and along said wharf to its northeast corner; thence in a straight line to the northwest corner of wharf owned by the California Wharf and Warehouse Company, and along said wharf to its northeast corner; thence to the northwest corner of McNear's Wharf, now rebuilding; thence along line of said wharf to the northeast corner of same; thence along the 30-foot curve as shown on the map herein referred to, to the ferry-slip at Port Costa; thence along said curve to the northwest corner of the Nevada Dock Company's wharf; thence along the 30-foot curve of the south side of the strait to a point of intersection with a center line of Seventh street, Benicia, prolonged; thence in an easy curve, essentially in 24 feet depth, as shown, to a point about 1 mile northeast of Martinez.

BENICIA AND NORTH SHORE OF CARQUINEZ STRAIT.

Bulkhead line.—Beginning at a point on the shore-line at mean low tide of the U. S. Army reserve, which point is situated about 600 yards northeast of the junction of the Government wharf with the railroad track; thence along an easy curve in a general westerly and southerly direction to the outer or southerly face of the Government wharf; thence westerly along this curve to the Agricultural Company's wharf; thence in a nearly right line to the shore end of the Southern Pacific Railroad Company's wharf; thence in easy curves, essentially as shown on the map of Peacock's survey by shaded lines, to Dillon's Point; thence essentially along the line of mean low water on easy curves to the easterly lines of the town of South Vallejo, the whole line is shown shaded on the tracing herewith.

Pier-head line.—Beginning at the southeast corner of wharf of Starr's flour mill at South Vallejo; thence following in a general southerly and easterly direction an easy curve, generally in 24 feet depth of water, low tide, to a point on this curve due south of Dillon's Point; thence following an easy curve, generally in 30 feet of water, in a general easterly direction along said curve to its intersection with the line of the Southern Pacific Railroad Company's ferry slip at Benicia; thence along an easy curve in a general easterly direction outside of the islands east of slip, the curve is described as follows: On southern prolongation of First street, Benicia, a point of said curve is 340 yards south of center line of main track of Southern Pacific Railroad, where said track crosses middle of First street. On prolongation of Second street said curve is 470 yards south of center line of main track; Third street, 550 yards south; Fourth street, 608 yards south; Fifth street, 660 yards south; Sixth street, 690 yards south, opposite the southeast corner of Baker & Hamilton's Agricultural Company's wharf said curve is distant, south of the center line of Southern Pacific Railroad Company's track, 700 yards. Opposite the southwest corner of the United States wharf said curve is distant from the center line of railroad track, due south, 150 yards.

EASTERLY SHORE OF MARE ISLAND STRAIT, COMPRISING THE FRONTS OF NORTH VALLEJO, VALLEJO, AND SOUTH VALLEJO.

Bulkhead line.—Commencing at a point on the southerly line of San Pedro street extended, 65 feet west of the westerly line of Alviso street; thence in a straight line to the foot of Main Street Wharf, 230 feet west of the westerly line of Santa Clara street; thence in a straight line to a point on the southerly line of Solano street, extended, 1,750 feet from the westerly line of Fifth street; thence in a straight line to the foot of Chestnut Street Wharf, 535 feet west of Third street; thence in a straight line to the southerly line of Atherton street, extended, 675 feet west of the westerly line of Second street; thence the line is continued along the mean low-water contour, and joins the bulkhead line projected for Carquinez Strait.

Pier-head line.—This is laid out in straight lines, commencing at a point where the southerly line of San Pedro street extended, intersects the contour of 18 feet, which point is 920 feet from the southwest corner of San Pedro and Alviso streets (as projected); thence to a point on the southerly line of Ohio street extended, 1,180 feet from the southwest corner of Trinity and Ohio streets; thence to the outer southerly end of the Georgia Street Wharf; thence to the southerly corner of the Monadnock Wharf; thence to the outer northerly corner of the Railroad Wharf; thence along the face of said wharf; thence from the southerly end of this wharf to Starr's Wharf, and along said wharf and the Mill Wharf to the southerly end of the latter, at which point it joins the pier-head line projected for Carquinez Strait.

MARE ISLAND NAVY-YARD.

Along the front of the navy-yard at Mare Island the naval authorities have established a bulkhead and wharf line, which is adopted by the Board. This line, as shown on the map of Mare Island Strait, was taken from a map furnished the Board by C. C. Wolcott, civil engineer, U. S. Navy.

There are transmitted herewith maps of Carquinez Strait and Mare Island Strait, upon which are delineated the bulkhead and pier-head lines as above established and described.

Respectfully submitted.

G. H. MENDELL,
Colonel, Corps of Engineers.
W. H. H. BENYAURD,
Lieut. Col., Corps of Engineers.
W. H. HEUER,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[First indorsement. On letter of transmittal.]

OFFICE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
August 1, 1890.

Respectfully submitted to the Secretary of War.

The Harbor-Line Board for San Francisco Harbor, California, and adjacent waters, constituted by Special Orders, No. 51, Headquarters Corps of Engineers, October 11, 1888, recommends for the approval of the Secretary of War the following harbor-lines described in the within report and delineated upon the accompanying chart:

(1) Bulkhead and pier-head lines, Port Costa and Martinez, south shore, Strait of Carquinez.

(2) Bulkhead and pier-head lines, Benicia and north shore of Carquinez Strait.

(3) Bulkhead and pier-head lines, easterly shore of Mare Island Strait, comprising the fronts of North Vallejo, Vallejo, and South Vallejo.

(4) Bulkhead and pier-head line, front of Mare Island Navy-Yard.

It is recommended that the lines selected be approved, and that the Secretary place his approval both upon the report and the tracings submitted.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

[Second indorsement.]

WAR DEPARTMENT, *August* 2, 1890.

Approved.

L. A. GRANT,
Acting Secretary of War.

APPENDIX R R.

IMPROVEMENT OF THE HARBORS OF REDWOOD, SAN LOUIS OBISPO, WILMINGTON, AND SAN DIEGO, CALIFORNIA.

REPORT OF LIEUTENANT-COLONEL W. H. H. BENYAURD, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Redwood Harbor, California.
2. San Louis Obispo Harbor, California.
3. Wilmington Harbor, California.
4. San Diego Harbor, California.

HARBOR LINES.

5. Establishment of harbor-lines in front of San Diego and Coronado, California.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., July 5, 1890.

GENERAL: I have the honor to transmit herewith reports upon the works under my charge for the fiscal year ending June 30, 1890. * * *

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Lieut. Col., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

R R 1.

IMPROVEMENT OF REDWOOD HARBOR, CALIFORNIA.

The project is to dredge Redwood Creek for a distance of about 6,000 feet, so as to give a channel 50 feet wide and 3 feet deep at low tide.

These dimensions are deemed sufficient for the accommodation of the vessels engaged in the trade with Redwood City. The upper reach of the creek, in the vicinity of the town, is very narrow, and as the excavated channel through that stretch takes up nearly the extreme width between the natural banks, any attempt to gain additional width would add greatly to the cost of the improvement.

The amount of commerce to be benefited is not considered as warranting the increased cost of providing for a wider channel under these circumstances.

At the close of the last fiscal year the creek had been dredged from the lower point of the Tannery Bend to a point a short distance below the upper limit of the projected channel. The cut was finished by July, and the dredge was then employed in going over portions of the channel previously dredged, widening and straightening the cut, and in giving it a uniform depth as far as practicable. The funds were exhausted in August, and the dredge was then sent to Stockton Slough.

The total amount of material removed during the operations of these two months was about 16,600 cubic yards.

The conditions existing at Redwood will prevent any improvement being of a permanent character. There being no tidal basin, there is a constant tendency to shoaling, due to deposits brought down from above and from the sliding in of the unstable banks. Dredging will have to be resorted to from time to time to maintain the channel in a navigable condition. An examination made in March last showed that the channel dredged in 1887 and 1889 had partially filled up from the causes mentioned above.

Any appropriation made for a continuance of operations will be expended in the maintenance of the channel-way heretofore dredged.

The total amount appropriated for this work is $15,400, and the total amount expended is $15,397.70.

Redwood is in the collection district of San Francisco, Cal., and the nearest lighthouse is at Yerba Buena Island.

Money statement.

July 1, 1889, amount available	$2,413.59
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	2,411.29
July 1, 1890, balance available	2.30

Statement of amount of commerce and navigation to and from Redwood City via Redwood Creek from July 1, 1886, to July 1, 1887.

[Furnished by Hanson & Co.]

Imports:		
Pine lumber	feet	4,250,000
Redwood lumber	do	1,200,000
Coal	tons	1,500
General merchandise	do	4,500
Hides, bark, oils, etc. (tanners' stock)	do	4,000
Exports:		
Redwood lumber	feet	5,000,000
Shingles		35,000,000
Split posts		425,000
Wood	cords	8,000
Tan-bark	do	3,500
Grain	tons	7,000
Hay	do	8,000
Tanners' goods (leather, glue-stock, etc.)	do	2,000

Statement of amount of commerce and navigation to and from Redwood City via Redwood Creek from January 1, 1889, *to December* 31, 1889.

[Furnished by Hanson & Co.]

Imports:		
Pine lumber	feet..	5,750,000
Redwood lumber	do...	4,000,000
Coal	tons..	2,500
General merchandise	do...	6,500
Tanners' stock (hides, barks, oils, etc.)	do...	6,200
Exports:		
Redwood lumber	feet..	5,800,000
Shingles		150,000,000
Posts, split		40,000
Fire-wood	cords..	5,400
Grain	tons..	5,200
Hay	do...	6,000
Tanners' goods (leather, glue-stock, etc.)	do...	4,000
Total amount of freight via Redwood Creek, July 1, 1886 to July 1, 1887	tons..	60,415
Total amount of freight via Redwood Creek, January 1, 1889 to December 31, 1889	tons..	70,786
Increase	do...	10,371

R R 2.

IMPROVEMENT OF SAN LUIS OBISPO HARBOR, CALIFORNIA.

The project is to construct a breakwater on Whaler's Reef extending from Point San Luis to Whaler's Island, and thence to a point where the outer reef rises above high water. The total length of the structure, when completed, will be about 2,300 feet. The breakwater is intended to afford a protected anchorage and landing at Port Harford. The effect of that portion of the structure already completed is observable in the reduced swell affecting vessels at the landing.

At the commencement of the fiscal year work was in progress upon the breakwater under contract with Rudolf Axman for furnishing and depositing stone on the reef. There had previously been deposited stone to the amount of 2,812 tons. With a continuance of the operations the gap between Point San Luis and Whaler's Island was closed, and a commencement was made upon that portion of the breakwater ouside of Whaler's Island. The initial appropriation of $25,000 was exhausted in October, at which time the contractor had deposited on the line of the reef a total of 6,596 tons of stone.

No stone of suitable quality for the breakwater, and in sufficient quantity to warrant the expense of quarrying, can be obtained in the vicinity of the work. The contractor experienced considerable difficulty in obtaining from the hills surrounding the bay the comparatively small amount of stone to fulfill the requirements of his contract. In future operations material will have to be brought from some distant point, probably from Moro Rock, 20 miles to the northward of the harbor. It is therefore desired that the appropriation be sufficiently liberal in amount to justify the furnishing of an outfit necessary to carry on the work in a proper manner. The amount of $125,000 can be profitably expended in continuing the operations during the next fiscal year.

The total amount appropriated for this work is $25,000, and the total amount expended is $24,990.70.

This work is in the collection district of San Francisco, and the nearest lighthouse is at Point San Luis.

Money statement.

July 1, 1889, amount available	$123.39
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	114.09
July 1, 1890, balance available	9.30
Amount appropriated by act of September 19, 1890	40,000.00
Amount available for fiscal year ending June 30, 1891	40,009.30
Amount (estimated) required for completion of existing project	219,900.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	125,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

[Furnished by Mr. J. M. Fillmore, manager of the Pacific Coast Railway, at San Louis Obispo, Cal.]

	Year the improvement began (1888).		Year ending December 31, 1889.	
	Incoming.	Outgoing.	Incoming.	Outgoing.
Vessels:				
Steam, number	603	603	466	466
Sailing, do	34	34	6	6
Total	637	637	472	472
Tonnage	452,149.34	452,149.34	471,327	471,327
Greatest draught, feet	18	.....	18	.....
Merchandise, general, tons	8,802	5,669	6,375	2,043
Coal, do	2,985	.....	616	.....
Lumber, feet	8,884,400	.....	4,590,100	.....
Grain, tons	.....	23,305	.....	17,626
Bituminous rock, do	.....	15,342	.....	12,019
Butter, do	.....	.....	.....	1,351
Cheese, do	.....	.....	.....	154
Live stock, do	.....	.....	.....	2,871

Total amount of freight entered and cleared in 1888, tons		68,425
Total amount of freight entered and cleared in 1889, do		49,421

No new lines of transportation have been established during the past year.

R R 3.

IMPROVEMENT OF WILMINGTON HARBOR, CALIFORNIA.

The improvement of this harbor was begun in 1871, at which time there was a depth at the entrance at low tide of about 1 foot. The operations carried on since have resulted in securing a greatly increased depth and width of channel. A depth of 12 feet at mean low tide can now be found throughout the whole length of the channel. The project now in course of execution is expected to increase this depth to 16 feet.

Operations during the past year consisted in keeping the work in order by repairing damages due to storms and high tides, and in dredging the inner channel. This latter work was not commenced until late

in May, owing to the fact that satisfactory bids could not be obtained. Failing to have the work done after due advertisement in the papers, efforts were made to induce parties owning or controlling dredging plants to undertake the dredging at prices that would be acceptable to the Government. An offer was finally obtained from Rudolph Axman, who proposed to build a dredge and excavate the channel between the Railroad Wharf and Deadman's Island at a price of 55 cents per cubic yard. This proposition was recommended to the Department for favorable consideration, and approved by the Secretary of War January 14, 1890. A contract was accordingly entered into with Mr. Axman for the removal of 85,000 cubic yards of material from the inner channel. This work was in progress at the close of the fiscal year, the contractor having excavated 13,498 cubic yards of material during the short period he was at work.

Specifications were issued June 25th calling for proposals for furnishing about 16,000 tons of rock for the west jetty. This material will be used in extending the jetty and in filling up the low part of the structure near Timm's Point.

During the coming season it is contemplated to continue the dredging operations, extend and raise the west jetty, and to keep the works in good order. These operations will be continued in the future to the extent of the funds available.

The total amount appropriated for this work is $870,000, and the total amount expended, including outstanding liabilities, is $752,005.82.

The balance of the amount required to complete the project can be profitably expended during the fiscal year ending June 30, 1892.

This work is in the collection district of Wilmington, and the nearest light-house is at Point Fermin.

Money statement.

July 1, 1889, amount available		$128,958.79
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$5,714.33	
July 1, 1890, outstanding liabilities	5,250.28	
July 1, 1890, amount covered by uncompleted contracts made during fiscal year ending June 30, 1890	40,068.50	
		51,033.11
July 1, 1890, balance available		77,925.68
Amount appropriated by act of September 19, 1890		34,000.00
Amount available for fiscal year ending June 30, 1891		111,925.68
Amount (estimated) required for completion of existing project		51,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

STATISTICS OF COMMERCE FOR THE YEAR 1871.

		Incoming.	Outgoing.
Vessels:			
Steam	number	160	160
Sailing	do	65	65
Total	do	225	225
Freight	tons	25,313	9,575
Lumber	feet	10,938,336	.....

STATISTICS OF COMMERCE FOR THE YEAR ENDING DECEMBER 31, 1889.

[Furnished by the collector of customs at Wilmington, Cal.]

	Foreign commerce.		Domestic commerce.	
	Incoming.	Outgoing.	Incoming.	Outgoing.
Vessels:				
Steam ..... number..	6	6	462	462
Sailing ..... do....	35	34	127	127
Total ..... do....	41	40	589	589
Tonnage	44,738	44,029	265,839	265,839
Draught, greatest ..... feet..	26	26	15½	.....
Merchandise, general ..... tons..	.....	.....	27,656	2,001
Coal ..... do....	67,620	.....	.....	.....
Lumber ..... feet..	49,379,000	.....	.....	.....

The total amount of revenue collected at the port during the year ending December 31, 1889, was $55,176.16.

The rates upon freight have been reduced since the first expenditure for the improvement of this harbor from $7.50 to 62½ cents per 1,000 feet on lumber, and from $5 to 50 cents per ton on general merchandise, from the outer anchorage.

Total amount of freight entered and cleared in 1871	tons..	50,059
Total amount of freight entered and cleared in 1889	do...	165,764
Increase	tons..	115,705

No new lines of transportation have been established during the past year.

R R 4.

IMPROVEMENT OF SAN DIEGO HARBOR, CALIFORNIA.

The work heretofore undertaken for the improvement of this harbor had for its object the control of the San Diego River, with a view of preventing the harbor from being a place of deposit of material brought down during flood stages. This improvement was completed in 1876. The work consisted in changing the course of the San Diego River, causing it to empty into False Bay. A substantial levee was built across the old river channel near its entrance into the harbor, and a new channel was cut, conducting the river into False Bay. Since the completion of this project, operations have simply consisted in keeping the levee in good condition. For this purpose small appropriations have been made from time to time, as circumstances required.

The Board of Engineer Officers, constituted by paragraph 3, Special Orders, No. 51, from Headquarters Corps of Engineers, October 11, 1888, to establish harbor-lines, submitted a report establishing the bulkhead and pier-head lines in front of San Diego and Coronado, which was approved by the Secretary of War April 2, 1890. A copy of the map of the harbor with the lines as established, was furnished the State board of harbor commissioners for San Diego.

Under the provisions of the river and harbor act of August 5, 1886, a survey was made of the entrance and outer bar at San Diego, and an estimate amounting to $394,400 was presented for constructing a jetty on Zuninga Shoals, and for dredging the middle ground just within the harbor entrance. Future appropriations made for the improvement of

the harbor, will be expended in carrying this project into execution, which is expected to increase the depth on the outer bar from 21 to 26 feet. Should the work be commenced under an appropriation this year, a further amount of $150,000 can be profitably expended during the next fiscal year in continuing the construction of the jetty.

The amount appropriated for this work since 1875 is $82,000, and the amount expended is $81,968.45.

This work is in the collection district of San Diego, and the nearest light-house is at Point Loma. The nearest fort is that begun at Ballast Point.

Money statement.

July 1, 1889, amount available	$81.55
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	50.00
July 1, 1890, balance available	31.55
Amount appropriated by act of September 19, 1890	60,500.00
Amount available for fiscal year ending June 30, 1891	60,531.55
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	150,000.00

COMMERCIAL STATISTICS FOR THE YEAR THE IMPROVEMENT BEGAN.

	Vessels.	Freight.
	No.	*Tons.*
Entered	201	24,809
Cleared	195	11,647

The vessels (including 109 steamers) had an aggregate tonnage of 122,311 tons.

COMMERCIAL STATISTICS FOR THE YEAR ENDING DECEMBER 31, 1889.

[Furnished by the collector of the port.]

		Incoming.	Outgoing.
Vessels:			
Steam	number	224	232
Sailing	do	106	97
Total		330	329
Tonnage	tons	212,390	211,802
Draught, greatest	feet	26	.....
Merchandise, general	tons	68,500	.....
Coal	do	56,527	.....
Lumber	feet	30,761,000	.....

Amount of revenue collected at the port during the year ending December 31, 1889, $62,091.58.

Total amount of freight entered and cleared in 1876	tons	36,456
Total amount of freight entered and cleared in 1889	do	166,691
Increase	do	130,235

No new lines of transportation have been established during the past year.

R R 5.

ESTABLISHMENT OF HARBOR-LINES IN FRONT OF SAN DIEGO AND CORONADO, CALIFORNIA.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., September 27, 1888.

SIR: In accordance with instructions contained in General Orders, No. 9, current series, from Headquarters Corps of Engineers, regarding obstructions in navigable waters, I have the honor to transmit herewith a map of San Diego Harbor, California, showing wharves as constructed and the proposed location of others for which franchises have been granted.

In addition to those referred to in my report of August 26, 1887, the map shows those constructed since that date along the city front and on the opposite side, at Coronado. Taken in order, commencing at National City, the wharves along the front are as follows: California Southern Railroad Company, Whitney's San Diego Lumber Company, Pacific Coast Steam-ship Company, Santa Fé Wharf, Carlson & Higgins, Jarres & Roseville.

The following wharf franchises have also been granted: Land and Town Company, three at Seventh, Eighth, and Ninth streets; Spreckels at G street, and Santee at D. The city authorities have also constructed a large sewer-tank, with pipe-connection to the shore, at the foot of H street.

No extended description of these structures is needed; the map fully indicates their position and extent. They are built regardless of the effect they may have in retarding and interfering with the tidal flow, and tend to impair the efficiency of the harbor. It is desirable that some supervision be exercised over these structures, as well as over other constructions in the harbor, to the end that the interests of navigation may be protected and the harbor preserved. The river and harbor act of August 11, last, provided for the establishment of harbor-lines at such places where they may be essential to the preservation and protection of harbors, and such lines, in my opinion, should be established in the bay of San Diego.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
October 8, 1888.

Respectfully submitted to the Acting Secretary of War, with recommendation that the Chief of Engineers be authorized to convene a Board of Engineer Officers, to consist of Col. Geo. H. Mendell, Maj. Wm. H. H. Benyaurd, Maj. Wm. H. Heuer, Corps of Engineers, to establish the harbor-lines of San Diego Harbor, under the act of August 11, 1888.

As the same matter is of great importance for the harbor of San Francisco, it is recommended that this same Board, if ordered, be

charged with the establishment of the harbor-lines of San Francisco and its adjacent waters.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

[Second indorsement.]

WAR DEPARTMENT,
October 9, 1888.

The recommendation of the Chief of Engineers is approved.
By order of the Acting Secretary of War:

JOHN TWEEDALE,
Chief Clerk.

REPORT OF BOARD OF ENGINEERS.

SAN FRANCISCO, CAL., *March* 14, 1890.

GENERAL: The Board of Engineer Officers constituted by paragraph 3, Special Orders, No. 51, from Headquarters Corps of Engineers, Washington, D. C., October 11, 1888, to establish the harbor-lines of San Diego Harbor and adjacent waters, has the honor to submit the following report:

The Board communicated with the mayor and common council of the city of San Diego, the Board of State Harbor Commissioners, and with others, for the purpose of ascertaining the views of, and receiving suggestions from, those interested in the establishment of a proper system of lines for the harbor. The Board of State Harbor Commissioners, through its chief engineer, presented the views of that body regarding the lines thought desirable to be established, and also placed at the disposal of the Board the recent surveys of the city-front of San Diego.

In addition to the information that could be derived from the latest coast-survey charts and other sources, the Board decided to make certain hydrographic surveys to ascertain the present condition of the harbor. This information was desired for comparison with former surveys and for a study of the changes that had taken place. The funds available from the appropriation for "improving harbor at San Diego, Cal.," to be applied to making this hydrographic survey, were insufficient to cover the entire area of the bay. Operations were therefore confined to a section of the bay extending from National City to the northerly limit of San Diego, covering those portions of the fronts of San Diego and Coronado now occupied by wharves, or along which it is contemplated to construct wharves in the near future. The Board is therefore only enabled to establish the bulkhead and pier-head lines in front of San Diego and Coronado, leaving the establishment of the lines at other points of the bay when funds are appropriated that will permit a continuance of the hydrographic survey.

There is transmitted herewith a chart, upon which the bulkhead and pier-head lines, as established by the Board, are shown. These lines are referred to certain fixed points, and are described as follows:

BULKHEAD LINE.—SAN DIEGO.

Starting from a point on the prolongation of the southerly side of Thorn street and 300 feet westward from the SW. corner of California street; thence in a straight line parallel to California street to a point on the prolongation of south side of Palm

street; thence to a point on prolongation of south side of Hawthorn street and 400 feet west of California street; thence parallel to Atlantic street to a point on prolongation of north side of Cedar street and 200 feet from Atlantic street; thence continuing parallel to Atlantic street to a point on the prolongation of north side of H street; thence in a curve of 300 feet radius with center at NE. corner of H and Atlantic streets to the prolongation of east side of Atlantic street; thence parallel to H street to a point on prolongation of west side of Arctic street; thence to a point on westerly side of Columbia street prolonged, 410 feet from SW. corner of Columbia and H streets; thence parallel to the westerly side of the right of way of the California Southern Railway Company and 200 feet from the same to the prolongation of the northerly side of S. Twentieth street; thence to the prolongation of northwesterly side of S. Twenty-first street and 1,020 feet from northeasterly corner of S. Twenty-first street and Pierce avenue; thence parallel to Pierce avenue to a point on prolongation of the southerly line of S. Twenty-fourth street; thence to a point on the prolongation of northwesterly side of S. Twenty-seventh street, 810 feet from easterly side of Pierce avenue; thence to prolongation of southerly side of S. Twenty-eighth street, 550 feet from SE. corner of Pierce avenue and S. Twenty-eighth street; thence to a point on prolongation of easterly side of Twenty-eighth street, 440 feet from the SE. corner of Twenty-eighth street and Colton avenue; thence to a point on prolongation of south side of S. Thirty-third street, 550 feet from west side of Avenue M; thence to a point on a prolongation of a line midway between Thor and Una streets and distant 450 feet from Pierce avenue; thence parallel to Pierce avenue to the prolongation of the boundary line between San Diego and National City.

BULKHEAD LINE.—CORONADO.

Starting from a point on the prolongation of Prospect street at a distance of 1,030 feet from the northerly side of Second street; thence to a point on the prolongation of the easterly side of Orange avenue and 450 feet from the northerly side of First street; thence to a point on prolongation of westerly side of K street, 250 feet from northerly line of First street.

The pier-head lines of San Diego and Coronado are laid out in straight stretches, following essentially the 24-foot contours on their respective sides of the bay. It is not possible to follow this contour absolutely. To avoid abrupt changes and to interfere as little as possible with tidal currents, some departure from that contour has been made at a few points. This has had the effect of giving a slightly increased or decreased depth at those points. The ruling depth, however, as adopted by the Board for the pier-head line, is 24 feet.

The approximate distance of the San Diego pier-head line from certain fixed points is as follows:

At Ivy street 6,850 feet from westerly line of California street.
At C street 3,740 feet from westerly line of Atlantic street.
On prolongation of Atlantic street 1,070 feet from southerly line of H street.
At Fifth street 4,180 feet from H street.
At S. Twenty-first street 2,090 feet from NE. line of Pierce avenue.
At S. Twenty-eighth street 1,390 feet from NE. line of Pierce avenue.
At Rigel street 2,400 feet from NE. line of Oliver avenue.
On prolongation of boundary line between San Diego and National City 3,350 feet from Oliver avenue.

The approximate distance of the Coronado pier-head line from certain fixed points is as follows:

On prolongation of Prospect street 1,175 feet from the NE. line of Second street.
On prolongation of Orange avenue 650 feet from the NE. line of First street; and
On prolongation of K street 1,300 feet from NE. line of First street.

The bulkhead and pier-head lines are laid out in straight lines. They are connected at the angles by curves, as follows:

When the angle of intersection does not exceed 12° by a 2° curve; from 12° to 24° by a 4° curve, and from 24° to 40° by a 6° curve.

G. H. MENDELL,
Colonel, Corps of Engineers.
W. H. H. BENYAURD,
Lieut. Col., Corps of Engineers.
W. H. HEUER,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
April 1, 1890.

Respectfully submitted to the Secretary of War.

The Harbor-Line Board for San Diego Harbor and adjacent waters, California, constituted by paragraph 3, Special Orders, No. 51, Headquarters Corps of Engineers, October 11, 1888, recommends for approval of the Secretary of War, certain harbor-lines in front of San Diego and Coronado, described in the within report and delineated upon the accompanying tracing.

It is recommended that the lines selected be approved, and that the Secretary place his approval both upon the report and the tracing submitted.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

[Second indorsement.]

WAR DEPARTMENT, *April* 2, 1890.

Approved.

REDFIELD PROCTOR,
Secretary of War.

APPENDIX S S.

IMPROVEMENT OF ENTRANCE TO HUMBOLDT BAY; OF SAN JOAQUIN, MOKELUMNE, SACRAMENTO, AND FEATHER RIVERS, AND PETALUMA CREEK, CALIFORNIA.

REPORT OF MAJOR WILLIAM H. HEUER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

IMPROVEMENTS.

1. San Joaquin River, Stockton and Mormon sloughs, California.
2. Mokelumne River, California.
3. Sacramento and Feather rivers, California.
4. Petaluma Creek, California.
5. Humboldt Harbor and Bay, California.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., July 2, 1890.

GENERAL: I have the honor to transmit herewith my annual reports of operations of the river and harbor works under my charge for the fiscal year ending June 30, 1890.

Very respectfully, your obedient servant,

W. H. HEUER,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

S S 1.

IMPROVEMENT OF SAN JOAQUIN RIVER, STOCKTON AND MORMON SLOUGHS, CALIFORNIA.

The project for the improvement of this river was adopted in 1887, and was slightly modified in 1881; its object was to secure and maintain, by dredging, a channel 9 feet deep, 100 feet wide, through the tidal parts of the river and Stockton Slough to Stockton, a channel 4 feet deep and 80 feet wide to Miller's warehouse, in Mormon Slough, and

the temporary improvement of the low-water channel by dredging, scraping small wing-dams, the making of cut-offs to straighten the river, and the closure, or partial closure, of Paradise Cut and Laird's Slough. Up to the present time there has been appropriated for use on this river the following amounts:

1876	$20,000	1886	$18,750
1880	20,000	1888	25,000
1881	40,000		
1882	40,000	Total	183,750
1884	20,000		

Of which up to date there has been spent $180,330.44.

When work was commenced on this river in 1877, there was only a low-water channel to Stockton of 6 feet in depth; the upper river was navigable for six to seven months in the year to Hill's Ferry for boats drawing 2 feet or less of water.

The commerce on the San Joaquin River is now carried on ten steam-boats and fourteen barges. The names of the steam-boats, their draught and tonnage, are as follows:

Steam-boat.	Draught.	Gross tonnage.	Steam-boat.	Draught.	Gross tonnage.
Centennial	2 feet	504	Empire City	18 inches	187
City of Stockton	3 feet	743	J. D. Peters	3 feet	880
Mary Garratt	....do	728	Merren	22 inches	119
A. C. Freese	2 feet	175	Leader	2 feet	400
Clara Crow	18 inches	98	T. C. Walker	3 feet	786

The tonnage of the barges varies from 660 to 150 tons, the average capacity of each barge being about 300 tons.

Work on the river and sloughs has been continuous when funds permitted.

Up to the fiscal year 1888 all of the dredging, snagging, dam-building, etc., was done by contract; the cost of dredging varied from 46 to 15 cents per cubic yard. In 1888 the Government, owning its own dredge, did its work by hired labor and brought the cost down to a little below 10 cents per cubic yard.

During the past year the dredge-boat was engaged in work for the Government at Redwood Creek, but returned to Stockton Slough in the latter part of August and worked in this slough till early in December, when high water prevented further operations. Her work for the short season aggregated 120,959 cubic yards of material in channels 16,198 feet in length and an average of 50 feet in width; the dredging was carried to a depth of 9 feet at low-water stage. The cost of this dredging was 5¼ cents per cubic yard.

The submerged dam built at Paradise Cut in December, 1888, is reported to have been washed out during the freshet of the past few months. This report has not been verified, and can not be until the river recedes, as it is yet nearly 2 miles wide, while its normal width at the dam-site is a little less than 250 feet. It would not be at all strange if the dam had washed out, as such a flood has never before been known in this locality. Should the dam have been washed out it is probable that to replace it will cost about $14,000.

A dam at Laird's Slough, near the town of Grayson, will also be required to improve the navigation of the upper river. Its estimated cost is $9,570.

Previous annual reports have recommended cut-offs at Twenty-one Mile Slough and Head Reach at an estimated cost of $125,000. No appropriation has yet been made for this purpose. Annual dredging will be required in Stockton Slough to maintain this channel for a good boating stage.

Without annual dredging steam-boats could not reach Stockton. Cut-offs where made have been self-maintaining. There has been no reduction in the rates of freight or insurance in consequence of the improvements, but if the improvements were discontinued it is probable that a material increase in both would soon follow.

With any future appropriations, depending upon amouns tappropriated and the requirements of commerce, it is proposed to continue work on the adopted project in the following order, unless Congress should otherwise direct:

1. Dredging to maintain 9 feet depth to Stockton	$24,000
2. Dams at Paradise Cut and Laird's Slough	23,570
3. Making one cut-off (Twenty-one Mile Reach or Head Reach)	65,000
4. Snagging and wing-dams	10,000
	122,570

The above can be advantageously expended in fiscal year ending June 30, 1892.

Application was made to the transportation company doing business on the San Joaquin River for statistics of trade of the river, but they were not received in time to be given in this report.

Money statement.

July 1, 1889, amount available	$10,690.88
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	7,296.32
July 1, 1890, balance available	3,394.56
Amount appropriated by act of September 19, 1890	75,000.00
Amount available for fiscal year ending June 30, 1891	78,394.56
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	122,570.00

S S 2.

IMPROVEMENT OF MOKELUMNE RIVER, CALIFORNIA.

The project for the improvement of this river was made in 1884, and had for its object the removal of snags and overhanging trees. The following appropriations have been made for this river:

In 1884	$8,500
In 1886	2,500
In 1888	2,000
	13,000

Both forks of the river were cleaned out during the years 1884, 1885, 1886, 1887, and 1888, and navigation made reasonably good to Benson's Ferry, which is the head of navigation.

When the improvement was commenced navigation was difficult on

account of the numerous snags and overhanging trees, 1,149 snags and 569 overhanging trees were removed, and the project as outlined was completed. During the past year no work has been done, as there was only $560.30 available. Steam-boat men have complained of a shoal bar in the river, and wanted one or two abrupt points cut off near New Hope Landing.

The commerce of this river is handled by one steamer, the *Constance*, 395 tons, whose draught light is 2½ feet, and loaded 6 feet, which makes three round trips per week. It is not believed that the improvements made on this river have occasioned any reduction in the rates of freight or insurance.

Complaint has been made that owners of private land near New Hope Landing had cut a canal which deflected the water at the mouth of the canal, caused a deposit or bar to form, and was injurious to navigation by making the landing of boats difficult. It is probable that the prolonged period of extremely high water this season will cause deposits and shoals, the bad effects of which will not be manifest or known before the low water sets in.

No work has been done nor money expended on this stream during the past fiscal year. At present the steamer has no trouble in carrying all the freight offered. It is thought that $2,000 can be advantageously expended in the fiscal year ending June 30, 1892, in removing snags lodged in the river since work in 1888 ceased.

The statistics of trade for the Mokelumne River, as furnished by the California Transportation Company as carried by their boats during the eleven months from July 1, 1889, to June 1, 1890, are:

Freight, in tons	39,144
Passengers	3,506

Money statement.

July 1, 1889, amount available	$560.30
July 1, 1890, balance available	560.30
Amount that can be profitably expended in fiscal year ending June 30, 1892	2,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

S S 3.

IMPROVEMENT OF SACRAMENTO AND FEATHER RIVERS, CALIFORNIA.

The project made and approved in 1874 had for its object the temporary improvement of the low-water channel by removing snags, building wing-dams, and scraping bars. Work has been continued ever since whenever funds were available. The total appropriations made for these rivers aggregate to date $465,000; the last appropriation, made in 1888, was for $20,000. At the end of the last fiscal year, June 30, 1889, the snag-boat was in commission on the upper river, between Sacramento and Butte City, and continued at work until the latter part of August, during which time she removed 705 snags and 70 overhanging trees; some of the snags had to be removed by blasting.

In December of 1889, in consequence of an extremely high river, caused by unusually heavy rainfalls, the levees on this river broke in several places. The most serious of these breaks occurred opposite to and about a mile below the city of Sacramento. Alarming reports of the condition of the river, the danger of its leaving its bed, seeking a

new channel, ruining navigation, etc., were telegraphed and mailed to Washington by prominent citizens. An examination and survey were ordered and made, but before the official reports of results of these surveys reached Washington, moneys which had heretofore been appropriated by Congress, but which were prohibited from being expended on account of alleged damages to the navigable condition of the river in consequence of hydraulic mining, were by joint resolution of Congress at once made available for removing damages caused by recent floods. It was asserted that hydraulic mining had ceased; this may have had some effect in releasing this unexpended balance heretofore tied up, but when these funds became available for the removal of damages caused by floods, then it was suddenly discovered by parties who desired to be paid for services rendered in the attempted suppression of hydraulic mining, that hydraulic mining had not yet ceased.

The crevasse above referred to was 825 feet in length and had an average depth of 12 feet of water running through it. Thousands of acres of farming land were inundated and people interested clamored for the closure of the crevasse. Their object can be conjectured, one was to have the money spent, another was to have it closed so that the farmers owning the inundated lands could plant their ground, but as neither of these reasons was a sufficient warrant for the expenditure of the money, it was then asserted that the navigation was being destroyed, that two-thirds of the water of the river was running through the crevasse, that a bar having only 1½ feet of water had formed just below the crevasse, etc. These reports failed to state that the very shallow bar did not extend half-way across the river, nor that the depth of water in the channel between the end of the bar and the opposite bank was 40 to 50 feet deep. Nor did those who made these reports consider what the consequences of the closure of the crevasse, at such a high stage of the river, would be to the levees above and below the crevasse, or that in the event of their failure to break, that it might cause an inundation of the city of Sacramento.

The surveys made soon after the break occurred showed the actual condition of affairs, and after due consideration it was proposed, in the interests of navigation and to prevent any liability of the crevasse becoming materially enlarged, to inclose the two ends of the broken levees by means of brush and ballast secured by piling and then to place brush mattress sills entirely across the opening of the crevasse. This method was approved, and bids for doing the work were advertised for. The following is an abstract of the bids received:

San Francisco Bridge Company, San Francisco, Cal.:

300 piles, 30 feet long, at 50 cents per foot	$4,500
Driving 300 piles, at $7 per pile	2,700
2,700 cubic yards of brush in place, at $4 per yard	10,800
10,000 bags filled with sand, at 50 cents per bag	5,000
1,800 running feet wale pieces, 4 by 12 inches, bolted to piling, at 30 cents per running foot	540
	23,540

American Bridge and Building Company, San Francisco, Cal.:

300 piles, 30 feet long, at 40 cents per foot	3,600
Driving 300 piles, at $11 per pile	3,300
2,700 cubic yards of brush, at $5 per yard	13,500
10,000 bags filled with sand, at 35 cents per bag	13,500
1,800 running feet of wale pieces, 4 by 12 inches, bolted to piling, at 50 cents per running foot	900
	24,800

J. G. McMahon, San Francisco, Cal.:	
300 piles, 30 feet long, at 50 cents per foot	$4,500
Driving 300 piles, at $6.50 per pile	1,950
2,700 cubic yards of brush, at $6 per yard	16,200
10,000 bags filled with sand, at 32½ cents per bag	3,250
1,800 running feet wale pieces, 4 by 12 inches, bolted to piling, at 20 cents per running foot	360
	26,260

As the prices were extortionate all bids were rejected and the work was re-advertised. The following are the bids received at the second opening:

James Simpson, Eureka, Cal.:	
300 piles, 40 feet long, at 35 cents per foot	$4,200
Driving 300 piles, at $6.50 per pile	1,950
2,700 cubic yards of brush, at $2.25 per yard	6,075
10,000 bags filled with sand, at 35 cents per bag	3,500
1,800 running feet wale pieces, 4 by 12 inches, bolted to piling, at 30 cents per foot	540
	16,265
John P. Sheldon, San Francisco, Cal.:	
300 piles, 40 feet long, at 22 cents per foot	2,640
Driving 300 piles, at $15 per pile	4,500
2,700 cubic yards of brush, at $1.69 per yard	4,563
10,000 bags filled with sand, at 47 cents per bag	4,700
1,800 running feet wale pieces bolted to piling, 4 by 12 inches, at 31 cents per foot	558
	16,961
California Bridge Company, San Francisco, Cal.:	
300 piles, 40 feet long Driving piles 2,700 cubic yards of brush 10,000 bags filled with sand 1,800 running feet wale pieces, 4 by 12 inches, bolted to piling	17,470
Thomas H. Williams, jr., San Francisco, Cal.:	
300 piles, 40 feet long, at 40 cents per foot	4,800
Driving 300 piles, at $9 per pile	2,700
2,700 cubic yards of brush, at $2.25 per yard	6,075
10,000 bags filled with sand, at 50 cents per bag	5,000
1,800 running feet wale pieces, 4 by 12 inches, bolted to piling, at 30 cents per foot	540
	19,115
San Francisco Bridge Company, San Francisco, Cal.	
300 piles, 40 feet long, at 30 cents per foot	3,600
Driving 300 piles, at $6 per pile	1,800
2,700 cubic yards of brush, at $4.95 per yard	13,365
10,000 bags filled with sand, at 49 cents per bag	4,900
1,800 running feet wale pieces, 4 by 12 inches, bolted to piling, at 20 cents per foot	360
	24,025
James A. McMahon, San Francisco, Cal.:	
300 piles, 40 feet long, at 40 cents per foot	4,800
Driving 300 piles, at $7.50 per pile	2,250
2,700 cubic yards of brush at $6 per yard	16,200
10,000 bags filled with sand, at 30 cents per bag	3,000
1,800 running feet wale pieces, 4 by 12 inches, bolted to piling, at $1.25 per foot	2,250
	28,500

The California Bridge Company also offered to do the work according to their own specifications for the sum of $16,840.

It was recommended to award the work to James Simpson, as the price was deemed reasonable.

From the time of the forming of the crevasse to the awarding of the contract was over four months. During this time several additional surveys of the crevasse and vicinity were made, and it was found that the crevasse had increased in width about 40 feet and increased in depth in places so that the maximum was 15 feet. During all this time the river was in a flood stage. On May 8, 1890, contract was made with James Simpson. He inclosed the ends of the levees, drove two rows and in places three rows of piles across the break, the piles being generally about 6 feet apart, and began filling in with brush and using bags filled with sand for ballast. The driving of so many piles caused a reduction in the cross-sectional area of the crevasse, produced a greater slope and velocity of water through the break, which in turn produced both a widening and a deepening of the crevasse to such an extent that its width became 1,095 feet, and scoured a hole in which the maximum depth was 24 feet. The driving of the piles from both ends toward the center in this rapid current was dangerous; they had to be driven from land drivers, as floating scows could not be held against the current. The land machines were in danger of overturning with every pile that was driven, and one of the pile-driver men was drowned. On June 21, the contract was completed in a satisfactory manner.

As the river was falling and there was no probability of another flood this season, and desiring to utilize the scouring power of the current to remove any shoaling which may have occurred in the river below and in consequence of the break it was decided to close the break by means of additional brush and ballast and to raise this barrier to a height of about 2 feet above the present level of the water in the river.

Bids for this additional material for the closure of the break were invited by advertisement, and contract made with Mr. James Simpson. The work will probably be completed before July 10, 1890.

The snag-boat and barge were hauled out on the ways at Benicia and were thoroughly overhauled and repaired. The repairs are about finished and both boats will be ready for snagging operations as soon as the navigation interests require it.

The snagging heretofore done has been of great benefit to navigation. Without it the navigation of the upper river would have been impossible. Freight and insurance rates were greatly reduced in consequence of the work done, and navigation is now safe. Snags will reform annually, and will have to be removed.

The boats plying above Sacramento all belong to one company hence there is no special inducement for them to make any further reduction in freight rates.

The rates of freight from places mentioned to San Francisco on wheat, the principal production of this section of the country, for the past few years has been as follows:

From—	Miles.	Per ton.
McIntosh to San Francisco	274	$3.00
Jacinto to San Francisco	241	2.50
Butte City to San Francisco	229	2.25
Moulton's Landing to San Francisco	219	2.00
Colusa to San Francisco	201	1.50

There has been no serious interference to navigation during the past fiscal year, but it is probable that in consequence of the recent exceedingly high and prolonged flood period, not yet passed away, that many more snags than usual have lodged in the upper rivers, and whether or not there will be any serious interference with navigation, can only be determined when the river falls from its present high state.

A resurvey of portions of the lower river will be made when the stage of the water permits, so as to ascertain what damage, if any, has resulted to the channel in consequence of the flood, and an estimate and project will then be submitted. It has also been recommended that a Board of Engineers examine and report on the condition of this river and submit plans for its improvement.

The commerce of these rivers is handled by the following steamers and barges:

Class.	Tons.	Class.	Tons.
Steamers and barges of the Sacramento Transportation Company:		Steamers and barges of the Sacramento Transportation Company—Continued.	
Steamers:		Brick barges—Continued.	
San Joaquin No. 2	242	I. G. Merritt	550
San Joaquin No. 4	365	Princeton	400
Varuna	216	Riverside	550
Governor Dana	364	Onisbo	550
San Joaquin No. 3	220	Sonoma	500
Jacinto		Steamers and barges of the California Transportation Company:	
Flora	185	Steamers:	
Dover	183	Pride of the River	619
Grain barges:		Onward	388
California	800	Aurora	406
Colorado	800	Relief	145
Utah	800	Sonoma	305
Dacotah	800	Barges:	
Denby Castle	700	Orient	378
Governor Hayes	600	Centennial	300
Granger	600	Sacramento	295
Nevada	800	Stockton	272
Arizona	800	Bessie	163
Idaho	800	Minnie	165
Mammoth	800	Thomas	115
Butte City	650	Steamers of the Southern Pacific Railway Company:	
Garfield	800	Vessels:	
Montana	800	Apache	460
Brick barges:		Modoc	445
Freeport	550		
Sutterville	550		

The above steamers and barges are all in use on the Sacramento River, the steamer *Herald* belonging to the Southern Pacific Railway Company makes one round trip to Marysville on the Feather River every week. Her gross tonnage is 293 tons.

With future appropriations, unless otherwise directed by Congress, it is proposed to continue snagging, building wing-dams, and scraping bars.

Money statement.

July 1, 1889, amount available		$122,367.99
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$47,954.62	
July 1, 1890, outstanding liabilities	21,618.47	
		69,573.09
July 1, 1890, balance available		52,794.90
Amount appropriated by act of September 19, 1890		30,000.00
Amount available for fiscal year ending June 30, 1891		82,794.90
Amount that can be profitably expended in fiscal year ending June 30, 1892. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		50,000.00

STATISTICS OF TRADE.

The following statement of the freight carried by the boats of the Sacramento Transportation Company, during the eleven months ending May 31, 1890, was furnished by Captain Roberts, of that company:

Freight up-stream:	Tons.
Lumber	26,400
Merchandise	33,800
Coal	4,000
	64,200
Freight down-stream:	
Grain	120,135
Wood	8,000
Brick	50,000
Merchandise	3,120
Live-stock	1,200
Produce	2,500
	184,955

The following statement of the freight carried by the boats of the Southern Pacific Railway Company was furnished by Captain Foster, superintendent of river steamers at Sacramento:

Freight carried on the Sacramento River:	Tons.
Freight carried north	431,026
Freight carried south	242,081
Freight carried on the Feather River:	
Freight carried north	44,284
Freight carried south	92,270

S S 4.

IMPROVEMENT OF PETALUMA CREEK, CALIFORNIA.

The project for the improvement of this creek was made in 1880; its object was to straighten the channel by cut-offs and to secure by dredging a channel 50 feet wide and 3 feet deep at low water.

Before improvement the channel was very crooked, and in places, at low water, the channel was dry. Dredging was done by contract, completed in 1884, and cost $27,656.91.

In 1888 the channel had refilled. It was again redredged by contract; 8,000 cubic yards of material were removed and deposited on the banks at a cost of $2,116.39. This relieved the immediate wants of navigation and produced a channel about 1 foot deep at low water and permitted vessels to enter from half-tides to high water. This channel can only be maintained by occasional dredging. Nearly all the drainage of this creek flows over highly cultivated agricultural land; the deposits are therefore large, and the commerce, as seen from the statistics furnished, is sufficiently large to warrant the obtaining and maintenance of a channel 4 to 5 feet deep, to obtain which it is estimated will cost about $30,000. This can be done in one year, and may require to maintain it dredging once every five years at a cost of about $5,000.

At present steam-boat men report that the channel has again deteriorated; that they are subjected to frequent delays in consequence of the shoals just below the town, but the amount of money available ($2,016.46) was too small to warrant the attempt at affording relief. As soon as more money becomes available temporary relief by dredging

will be afforded. It will, however, be more economical and advantageous to dig a deeper channel, as recommended in previous years' reports, and then when once obtained dredge less frequently.

The commerce of the creek is carried by one steam-boat, the *Gold*, of about 294 tons capacity, making 6 round trips per week, and several small schooners, two of which run to Petaluma as regularly as wind and weather permit.

Appropriations made to date are	$32,000.00
Expenditures to date are	29,983.54
Balance available	2,016.46

Money statement.

July 1, 1889, amount available	$2,016.46
July 1, 1890, balance available	2,016.46
Amount appropriated by act of September 19, 1890	4,000.00
Amount available for fiscal year ending June 30, 1891	6,016.46
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	30,000.00

COMMERCIAL STATISTICS.

The following statistics of trade for Petaluma Creek were supplied by a committee specially appointed by the board of trustees of the city of Petaluma:

Bricks and paving-stone	number	900,000
Coal	tons	3,225
Eggs	dozens	818,748
Building material	tons	927
Hides, etc	number	23,153
Grain and feed	tons	15,175
Lumber	feet	3,626,403
Live-stock	number	65,690
Merchandise	tons	80,648
Products	do	55,619
Passengers	number	19,801
Shingles	do	20,100,000
Vehicles	do	736
Wine	gallons	95,000
Wood and bark	cords	3,540

S S 5.

IMPROVEMENT OF HUMBOLDT HARBOR AND BAY, CALIFORNIA.

The project for improvement was adopted in 1881; it aimed to secure a channel 13 feet deep, 200 feet wide to the head of the Eureka wharves and one of 10 feet deep and 100 feet wide to Arcata and Hookton. In 1882 an additional project was made to increase the depth of water over the bar at the entrance to Humboldt Bay by means of a training-wall built up to low water-level and extending from the shore on the south spit seaward in a northwesterly direction for about 6,000 feet, the estimated cost of which was to be about $600,000.

The dredged channels inside the harbor were completed in 1884. As they are not self-maintaining, they have since partly refilled. Ninety-

six thousand and sixty-one dollars and fifty-five cents was spent on this part of the project, principally for dredging.

For improving the entrance to the harbor appropriations were made in 1884, 1886, and 1888, aggregating $262,000, but as the separate appropriations were small and could not be used until certain land required was obtained free of expense to the Government, contracts for doing the work could not be made until the latter part of 1888, when, after due advertisement, a contract was made with the American Bridge and Building Company to do about $250,000 worth of work, consisting of railroad track, pier-work, rock and brush work, their work to be completed on December 31, 1889. Up to the end of June, 1889, the contractor had completed 1,605 feet of shore track, had built a portion of pier over water, 1,152 feet (linear) of shore protection wall composed of brush and stone; about 6,206 tons of rock and 3,303 cubic yards of brush were used in the construction.

Work of extending the trestle in the water, from which to build the jetty, consisting of brush and stone, was carried on until December 6, 1889, when the weather became too bad for further operations. In this time, July 1 to December 6, a little over five months, 24,512 tons of rock and 14,669 cubic yards of brush were delivered into the jetty, and 2,767.6 linear feet of pier were built. The shore work, pier-work, and brush work were practically completed at the close of the season, but only about three-eighths of the quantity of rock required was delivered up to the time of the expiration of the contract. The contractor asked for and obtained an extension of time of ten months in which to complete his delivery of rock; this was granted as provided for in the terms of the contract. The extension expires October 31, 1890. From December, 1889, to April, 1890, was an unusually severe rainy season and but little work was or could have been done. At the latter end of May work at the quarries was resumed, and up to June 30, 1890, 3,448 tons of rock, making a total for the fiscal year of 27,678 tons of rock, were delivered, and leaving a balance of about 52,420 tons yet to be delivered before the expiration of the contract.

The jetty is now in the following condition: Length from shore outwards, 3,039.7 feet; average width of base, 45 feet; this is brush-work, whose average height from top to bottom is 4 feet 6 inches. In building the trestle-work the shore advanced until low-water mark was 700 feet from the starting-point; over this distance the brush-work was built in place on the sand; from this point outward the brush mats were built and supported on piles slung across the trestle-work under the caps and were dropped at slackwater. The general depth of water where the jetty was built was 3 to 5 feet at low water, except where an old channel was crossed about 50 feet wide; here the depth was 8 feet at low tide. After the mats were sunk and ballasted, the sand scoured away in front of the mats, and in the outer 800 feet of jetty they were sunk in from 8 to 12 feet depths at low water.

It required about 6 tons of rock per running foot to properly sink and hold the brush mats; the balance of the rock was used in raising the shore end to high water. At present the height of the top of jetty (rock) is as follows:

The first 900 feet up to level of high water. The next 384 feet between high and low water. The next 1,600 feet between low water and 2 feet below. The outer 156 feet from 3 to 6 feet below low water.

The changes in the channel for the last six months have been frequent, but whether these changes were caused wholly or in part by the

jetty it is difficult to decide. These changes occur each year, but not to the extent of the last season. The channel over the bar has been good; from 15 to 20 feet at low water. Most of the changes were at the entrance and caused by the washing away of the North Spit. There is now 16 feet at low water, but the channel it narrow.

The North Spit has washed away in the year 2,000 feet, most of it since January 1st; the South Spit remains nearly the same except near the jetty. On the north side of the jetty the high-water line is unchanged; the low-water line has receded 500 feet, which makes the distance between high and low water 200 feet; one year ago it was 700 feet. On the south side of the jetty the sand has made out, high-water line having advanced 600 feet and low-water line 300 feet during the year.

The shortest distance between high and low water lines from North to South Spit is as follows:

June, 1889, between high water 3,000 feet, low water 2,100.
June, 1890, between high water 4,300 feet, low water 3,500.

That is, the entrance has widened 1,300 feet between high-water and 1,400 feet between low-water lines during the year.

While the storms of the past year have been unusually violent but little damage has been done to the work; some of the smaller rock nearer the shore has been scattered about by the violence of the wave action. Experience of the past year has taught us that the jetty can be made to stand and do the work required. No material increase in depth of water over the bar has yet been produced, nor was it expected that such a small portion of jetty as has been completed would produce any decided result. Sands have accumulated rapidly on both sides of the jetty as it was extended, and this is the best evidence desired that the rock placed in the jetty will remain. A great many changes in the North Spit have occurred in consequence of the construction of the south jetty. These changes will continue as the south jetty advances until a state of equilibrium is reached, and the time has come when a Board of Engineers should be convened to examine into what has been done, determine whether or not a second jetty is essential, and whether either or both jetties should not be raised to a higher level than was at first thought necessary.

The wooden pier, by means of which the jetty underneath was constructed, is subject to destruction by teredo and also by violent wave action. With the heavy seas rolling against this jetty and pier, it is extremely probable that the pier will not last longer than one year more. It cost us at the rate of $5.50 per running foot, and as there is a little over 3,000 feet of it, its cost was about $16,500. To replace this, piles would have to be driven through the rock in the jetty, which would cost more than twice as much as the original construction where the piles where driven through sand, and as there will be in all about 6,000 linear feet of this pier, it can readily be seen, from an economical point of view, how important it is to complete this jetty before the wood-work carries away, and the rapidity with which the jetty can be constructed depends entirely upon the amount of money appropriated by Congress. To complete a low jetty as projected will cost $337,500 in addition to what is now available. If the jetty should be raised higher, and I deem it essential that it should be raised at least to the level of the highest high tide, the cost will be greatly increased.

The work was in local charge of Assistant Engineer W. P. Smith and Inspectors Frank A. Burt and W. D. Woodbury, each of whom rendered valuable services to the Government.

With future appropriations it is proposed to continue work on the adopted project in extending the training-wall on the South Spit.

Money statement.

July 1, 1889, amount available	$6,819.49
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	5,844.65
July 1, 1890, balance available	974.84
Amount appropriated by act of September 19, 1890	80,000.00
Amount available for fiscal year ending June 30, 1891	80,974.84
Amount (estimated) required for completion of existing project	257,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	257,500.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

The following statement of the freight carried by the steamers of the Pacific Coast Steam-ship Company between San Francisco and Eureka during the eleven months from July 1, 1889, to May 31, 1890, was kindly furnished by Messrs. Goodall, Perkins & Co.:

Articles.	To Eureka.	From Eureka.	Articles.	To Eureka.	From Eureka.
Cereals ..... tons..	16.7	216.1	Lumber ..... tons..	24.0	7,511.7
Produce ..... do...	420.8	776.8	Merchandise ..... do...	3,330.7	1,374.7
Coal ..... do...	193.7	.....	Miscellaneous ..... do...	210.7	100.2
Flour ..... do...	844.9	.....	Fish ..... do...	.....	197.5
Household goods .... do...	146.7	147.8	Wool ..... do...	.....	75.5
Hides and pelts ..... do...	1.6	5.4			
Iron castings ..... do...	121.5	85.7	Total	5,439.9	10,569.7
Liquors ..... do...	119.1	.....	Treasure ..... amount..	$185,462	$138,779
Building material ... do...	9.2	.....	Passengers .... number..	3,514	4,242
Live stock ..... do...	.3	78.3			

There were cleared from the port of Eureka during the eleven months from July 1, 1889, to May 31, 1890, for foreign ports, 13 schooners, 5 barkentines, 2 barks, with a total tonnage of 5,854 tons, carrying 5,793,000 feet of lumber valued at $96,150. This information was kindly supplied by the Hon. Thomas Cutler, collector of the port.

APPENDIX T T.

IMPROVEMENT OF THE ENTRANCE TO COOS BAY; IMPROVEMENT OF YAQUINA BAY, OF COQUILLE RIVER, OF UMPQUA RIVER, OF TILLAMOOK BAY AND BAR, OREGON; OF UPPER COLUMBIA AND SNAKE RIVERS, OREGON AND WASHINGTON; OF CHEHALIS RIVER, AND OF SKAGIT, STEILAQUAMISH, NOOTSACK, SNOHOMISH, AND SNOQUALMIE RIVERS, WASHINGTON.

REPORT OF CAPTAIN THOMAS W. SYMONS, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

IMPROVEMENTS.

1. Coquille River, Oregon.
2. Entrance to Coos Bay, Oregon.
3. Umpqua River, Oregon.
4. Entrance to Yaquina Bay, Oregon.
5. Tillamook Bay and Bar, Oregon.
6. Upper Columbia and Snake Rivers, Oregon and Washington.
7. Chehalis River, Washington.
8. Skagit, Steilaquamish, Nootsack, Snohomish, and Snoqualmie rivers, Washington.

EXAMINATIONS AND SURVEYS.

9. Young's River and its tributary, Klaskuine River, Oregon.
10. Nehalem Bay and Bar, Oregon.
11. Siuslaw River and Bar, Oregon.
12. Umpqua River, Oregon, between Scottsburgh and the mouth.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, July 10, 1890.

GENERAL: I have the honor to forward herewith the annual reports for the fiscal year ending June 30, 1890, for the works of improvement of rivers and harbors under my charge.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

T T 1.

IMPROVEMENT OF COQUILLE RIVER, OREGON.

DESCRIPTION OF ORIGINAL CONDITION.

At the time the work of improvement was begun the entrance to the Coquille River was considered very dangerous. It was by a long, tortuous, and narrow channel, skirting the south headland, studded with rocks from beyond the bar on the outside to a distance of one-half mile inside. The depth at low water over the bar was only about 3 feet; and the position of the bar channel was constantly shifting. The channel sometimes, at long intervals apart, broke through the north spit and ran directly out to sea just south of Rackliffe Rock, but did not remain long in this position. The entrance at such times was comparatively safe, and the channel was at its very best. The mean rise of tide was 4.1 feet.

PLAN OF IMPROVEMENT.

The plan of the improvement is to construct two parallel, high-tide stone jetties, 800 feet apart, running out to sea at sufficient distance to open and maintain a channel over the bar with a least depth of 8 feet at low water; the north jetty starting from Rackliffe Rock, and the south jetty from a point on the left bank inside the entrance. The cost of this work, as estimated in 1878 by Maj. J. M. Wilson, is $104,200. The law of August 11, 1888, authorized in addition, $5,000 to be expended for snagging between Coquille City and Myrtle Point.

APPROPRIATIONS.

Act July 14, 1880	$10,000
Act August 2, 1882	10,000
Act July 5, 1884	10,000
Act August 5, 1886	20,000
Act August 11, 1888	25,000
Total	75,000

AMOUNT EXPENDED TO JUNE 30, 1889.

The amount which had been expended on the project for the improvement of the mouth of the Coquille to June 30, 1889, was $67,822.67.

RESULTS OBTAINED TO JUNE 30, 1889.

The channel through the north spit was opened in 1882, after the construction of about 1,000 feet of temporary jetty; and soon after the old channel was completely filled up and the jetty across it covered with sand and drift. The new channel when well opened gave a depth of 7 feet at low water over the bar. During 1884 some of the temporary jetty was destroyed by drift, and the adjacent fill was washed out, so that a portion of the outflow escaped uselessly to the south among the rocks, causing a shoaling up of the channel over the bar to a depth of 5 feet. In 1885 the jetty was repaired and extended out to a length of 1,523 feet, giving a channel depth of about 6 feet at low water. During the

season of 1886–'87 an extension of 403 feet was made to the jetty pile. work, and the jetty was partly completed by the addition of stone. During 1889 the jetty was still farther strenghened and extended, with the result that the ordinary high-water depth on the bar was 11 feet, while during a part of the time a depth of 20 feet was obtained.

AMOUNT EXPENDED DURING YEAR ENDING JUNE 30, 1890.

The amount expended during the year ending June 30, 1890, was $7,025.81. Of this amount, about $4,000 was expended in snagging on the river between Coquille City and Myrtle Point, under the clause in the appropriation bill which authorized the expenditure of $5,000 for this purpose.

RESULTS OBTAINED TO JUNE 30, 1890.

The results of the work already done at the mouth of the Coquille are in the highest degree satisfactory; there being now a straight channel out to sea with a depth of 10 feet at low water. This result is better than that which the Board of Engineers hoped to obtain by the completel work. From the outer end of the jetty a deposit of sand tails out, forming a well-defined, low sand-jetty or training-wall in direct prolongation of the jetty, and on the north side sand has been deposited parallel with the jetty, and nearly up to low water, at a distance of about 800 feet from it, forming also a low, sand training-wall, which, all togther, direct the ebbing and flooding tides and river-waters in a straight and deep channel out over the bar to sea. This result has been hastened very materially by the removal of the mid-channel rock just inside the entrance, which has so long been a terror to mariners, and the cause of many accidents. This rock was drilled and prepared for blasting, but the appropriation became exhausted before this was done. Recognizing the importance of its removal, and the fact that the best time of the year to do it was during the low tides of June, the citizens on the river contributed the necessary labor, powder, and other material for its removal, this office supplying only the blasting machine and the skilled supervisor, and on June 5 the blast took place successfully, and the rock was entirely demolished and disappeared.

The snagging and bar scraping done on the river between Coquille City and Myrtle Point was productive of great good to the navigation of the river. The freshets of the last winter and spring (unprecedented in volume) have, however, again deposited many snags on the river which should be removed.

REPORT OF OPERATIONS FOR YEAR ENDING JUNE 30, 1890.

The operations for the year consisted in removing snags from the river between Coquille City and Myrtle Point and scraping the bars, so as to render the river navigable by light-draught steamers, and in constructing dump-cars for use on the jetties at the mouth of the river. One car was completed and ten others nearly so. Active operations were suspended on December 31, 1889. On June 5, 1890, the large rock in mid-channel, nearly opposite Rackliffe Rock, in which holes for blasting were drilled in the fall of 1888, was successfully removed by blasting. One large blast of 750 pounds Hercules No. 1, and a small one of 50 pounds, were made, resulting in giving a least depth of 10 feet at mean low water on the former site of the rock.

COMMERCIAL STATISTICS.

The mouth of the Coquille River is in the collection district of southern Oregon. Empire City, on Coos Bay, is the port of entry. The nearest light-house is on Cape Arago, 12 miles northward. The principal industry of the valley is lumbering; the timber is a good quality of fir, white cedar, spruce, ash, and myrtle. A fleet of schooners carries the product to San Francisco and brings back supplies. There is some vessel-building on the river. The upper part of the valley is agricultural. The dairy and grazing region half-way south to Port Orford finds an outlet at the mouth of the Coquille. Coasters ascend to Coquille City, 28 miles, and the river is navigated by light-draught vessels to Myrtle Point.

The following information is obtained from statements furnished by the Coquille Mill and Tug Company, Parkersburgh, Coos County, Oregon, applicable to the year ending June 30, 1890.

The following is a list of business on the Coquille River, as far as we can ascertain:

Schooners—		
Eight	average tonnage..	375
Three	do	Unknown
Three	do....	30
Vessels—		
Arrived	number..	53
Cleared	do....	52
Built	do....	2

Exports and imports.

	Tons.
Exports—	
Lumber	19,500
Imports—	
General merchandise	3,500

The draught of vessels trading to Coquille is, when loaded, from 7 to 9 feet.

On the river the steamer *Antelope* plied between Bandon and Coquille City, 23 miles; round trip each day.

Steamer *Little Annie* between Bandon and Coquille City; average two trips a week; mostly freight.

Steamer *Ceres*, Coquille City to Myrtle Point, 14 miles; round trip each day.

Tug *Katie Cook* was used for bar work.

Average passengers each day, 20.

End of year steamer *Little Annie* struck on rock near Bandon, sunk, and total wreck.

Schooner *Parkersburgh* lost wind while sailing in; went on beach, but was gotten off with very little expense.

RECOMMENDATIONS AND REMARKS.

In order to maintain the existing good channel out of the Coquille, it will probably be necessary to extend the south jetty several hundred feet further, and to construct the north jetty as planned by the Board of Engineers. The next appropriation will probably extend the south jetty as far as at present necessary, and after that the north jetty should be commenced; and as this will require a change of plant, and of the method of doing the work, it is recommended that the next appropriation be at least $50,000 for the mouth of the river.

It is further recommended that $5,000 of this amount be authorized to be expended on the river from Bandon to Myrtle Point, in removing snags, rocks, bars, log-jams, etc.

Money statement.

July 1, 1889, amount available		$4,651.78
July 1, 1890, amount expended during fiscal year exclusive of liabilities outstanding July 1, 1889	$4,500.26	
July 1, 1890, outstanding liabilities	45.50	
		4,545.76
July 1, 1890, balance available		106.02
Amount appropriated by act of September 19, 1890		30,000.00
Amount available for fiscal year ending June 30, 1891		30,106.02
Amount (estimated) required for completion of existing project		64,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		50,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. R. S. LITTLEFIELD, INSPECTOR.

EMPIRE CITY, OREGON, *June* 17, 1890.

CAPTAIN: The operations, Coquille improvements, for the present fiscal year, consist in snagging the upper river between Coquille City and Myrtle Point; the construction of 11 dump cars, so far as the wood-work was concerned, for use at the jetty; the removal to higher ground of jetty locomotive, hoisting machinery, coal, etc., which had been left exposed to storm-tides by Norman F. Jenks, late superintendent at time of suspension of work about the jetty on June 9, 1889; blasting the previously drilled rock in mid-channel, just inside the river entrance, took place June 5 of the present month. Most of the snagging was done under the direction of Mr. Jenks, during months of July to middle of August, when he was relieved; the operations were then continued by Mr. David Hutchinson, foreman, to the middle of October, when the above mentioned machinery was properly secured, and the car work done by end of the calendar year.

I am without data here for making a detailed report of the snagging operations, but in brief, they consist in blasting trees, stumps, and logs in worst places in channel of the river between the points named, using Hercules powder No. 1, and a pile-driver fitted up to hoist the pieces out of the immediate channel. One place called "Nancy's Pinch" about 10 miles above Coquille City, was a net-work of snags, forming at all times, except on a considerable rise of tide, an obstruction bar to the light steam-boat navigation of that part of the river. Snags were removed at places less obstructed, and isolated ones pulled out on the whole reach of the river, Coquille City to Myrtle Point, a distance of 14 miles. For a mile or so below Myrtle Point, which is on south fork of the Coquille, that distance up, gravel and sand-bars were scraped through, using teams, but the benefit was temporary only. Still a great deal of myrtle timber, forming snags, was removed from bed of the river on this stretch.

The navigation was accounted very much improved by these operations, but the freshet of February last brought into the river a fresh supply of snags and tended to form shoals at new places, so that the work ought to be gone over again. Even now the waters of the upper river are not clear, owing to vast land-slides on the forks On February 4 I paced on bank of the river, just above Coquille City mill-boom, along a raft of trees filling the stream from bank to bank a distance of one-half mile. the raft was wedged, and of thickness varying from 2 feet to nearly the channel depths. This raft was broken up piecemeal and started down the river by the citizens of Coquille City, mainly by Mr. Lyons, of the mill company, and his force during four days after lodgment. Considerable of the timber was valuable, which was saved by tying it up in eddies of the river below Coquille City. The timber was mainly green fir and cedar, from a mountain land-slide on south fork of the river, above navigation. No damage was done the jetty at mouth of the river, the water there owing to free discharge of the flood not being as high as during a storm-tide in fore part of January, when 220 feet length of the newly constructed track or tramway at end inshore, where laid on or near the ground, was swung by the tide and left nearly at a right angle to the line it was built upon. This tramway was made in May, 1889, under Mr. Jenk's supervision, and ran on a down-grade from the jetty in to the beach at bluff, instead of construction without grade, as planned and provided for in the bill of materials; hence the section torn up was in the surf which carried

drift-logs during the January high-tides mentioned. The whole tramway of May, 1889, will require raising and rebuilding. The February freshet, unprecedented for volume, produced an extension seaward to the north spit and a turn of it south, reported by Captain Parker, of Coquille Mill and Tug Company, to be about on site of the bar, so for over a month in towing the alignment of the jetty was crossed to the southward toward the exterior rocks; but this deposit, probably wholly from the river, was very narrow (it showed so at low water), and gradually disappeared. After a time the channel changed its old time position parallel to the jetty's direction, and as this result was neared the action was hastened by frequent crossings made back and forth by Captain Parker's new and powerful tug.

The mid-channel rock, just inside the entrance to the river, was egg-shaped, the small or northerly end up-stream, and at mean low water of the harbor was uncovered 0 to 2 feet high for a length of about 23 feet, and extreme width, 18 feet (the tides of June fall 2 to 3 feet below mean low water.) The large end south was submerged at mean low water for an additional length of about 10 feet; beyond it sloped into deep water 8 to 10 feet further, so that its total length was about 41 feet, with a width total at large end of about 20 feet.

During recent years, when work on the jetty was in progress, generally late in the season, when low tides occurred at night and were much higher than the extreme June ones, I had the rocks drilled by hand, thirteen holes in number, making squares of about 4 feet, and under Captain Powell's instructions, officer in charge, springing them when 10 feet deep, so there were chambers formed at this depth by measurement, 8 inches in diameter by 10 inches high. Capt. Willard Young, Corps of Engineers, who, in July, 1887, relieved Captain Powell of charge of works in this district, directed that the holes be deepened 2 feet, and more, if practicable; and using heavy churn drills, they were all brought to a least depth of 12 feet below mean low water; some slightly in excess of that depth. The rock was hard sandstone.

At times, owing to shifting of the channel in locality of the rock, it would be buried deep in deposit, one year in south bank, another year in north spit, opposite where the rock belonged previous to the commencement of works for improvement at this harbor; then for seasons its position was in direct center of the channel, a menace to every passing vessel, covered as it was at usual times (flood-tides) for vessels to pass. The conditions for blasting the rock the present month were at the best, and like conditions existed in June, 1889, for the currents having about equal division by the mass, had scooped out around the rock's base to nearly double the depth of water immediately above and correspondingly below. After pumping out several times the holes, which were filled with gravel, sand, etc., also the chambers and crevices, an examination made by diver Burke developed that there were cavities or overhanging shelves to the rock on opposite sides near the bottom. The holes were charged with Hercules No. 1 powder, using about one-half of the 750 pounds purchased for the work, and the balance was stowed away in sacks by the diver under the shelves mentioned, and the whole charge was fired by an electric machine operated by Mr. Alex. McMillan, C. E., at a point distant 425 feet. Mr. McMillan had made all the necessary wire-connections to each hole and the sacks. The rock was well demolished, but examination by the diver showed a block of stone about 4 feet square was left on top of a pile of smaller ones, on which a sounding, mean low water, was 6 feet; 50 pounds additional of the same brand of powder was exploded under the heap, and examination afterwards, following some work done by the diver, leveling, gave a least low water (mean) 10 feet on site of the rock, with general depths 12 feet and over.

The whole expense for labor, powder, and other materials, was borne by citizens of the river most interested in navigation, who cheerfully gave every necessary help. A main contributor, Captain Parker, states that damage to vessels on account of collisions with the rock, since it was drilled for blasting, aggregates $1,000. The date of the blast, main one, was June 5, 1890.

The channel along outer half of the jetty, and on over the bar, is parallel to the jetty's direction, and in location about 100 feet north. Soundings from on board the bar tug, taken June 7, showed as least depth on the bar, one cast, 104 feet. The removal of the rock may have a perceptible effect for betterment to the Coquille Bar.

There are two other rocks which obstruct navigation of the river; one, a small rock at first turn one-fourth of a mile above Bandon, and another nearly the size of the one blasted opposite Randolph, 6 miles above. Examination I had made by the diver, 7th instant, indicates that neither rock requires to be drilled; the Randolph one having a large cavity for advantageous stowage of the necessary powder.

There are many isolated snags between Bandon and Coquille City; the place last named is at head of vessel navigation, and on account of snags, the river is shoal just above Parkersburgh.

Respectfully submitted.

R. S. LITTLEFIELD,

Capt. THOMAS W. SYMONS,
Corps of Engineers, U. S. A.

T T 2.

IMPROVEMENT OF ENTRANCE TO COOS BAY, OREGON.

DESCRIPTION OF ORIGINAL CONDITION.

The obstructions which existed at the entrance to this harbor before the works of improvement were begun consisted, first, of the outer bar, which is of sand and is shifting in character; and secondly, of the inner shoals formed by the sands which accumulate in the spring, summer, and autumn, during the times when the northwesterly winds prevail.

Under the action of these winds the spit on the north side advanced toward the south, contracting the navigable passage under Coos Head to a very narrow width, and usually making the outer channel follow the west side of the spit in a long and tortuous course across the bar.

The channel had at times broken through the north spit on a line the general direction of which is from Fossil Point to a point just to the north of Coos Head. It was then direct, the depth of water was greatest, and vessels could enter or go out without trouble. The mean rise of tide above the plane of reference was 5.6 feet.

PLAN OF IMPROVEMENT.

The project for this improvement, adopted in 1879, is to construct, at an estimated cost of $600,000, a jetty of wood and stone, as may be found best, from a point 250 yards below the northern extremity of Fossil Point, on a line towards the east end of Coos Head, this line in plan curving so as to be directed at its outer end to the head or a little to the north of it.

The object is to prevent accretion to the south end of the sand spit on the north side of the entrance, and to open and maintain a deeper and more direct channel across the outer bar.

A Board of Officers of the Corps of Engineers has submitted a report embodying an additional project and estimate of the cost of completing it for the improvement of the entrance to the harbor of Coos Bay. Their report is herewith. This board recommend that the present jetty be not further extended, but that two jetties be built, one from Coos Head and one from the southern end of the North Spit out towards the bar ending at a distance apart of about 1,500 feet.

The estimated cost of the work proposed by the Board of Engineers, is $2,466,412.20. This report also alludes to the desirability of holding the drifting sands of the North Spit.

APPROPRIATIONS.

Act of March 3, 1879	$40,000
Act of March 3, 1881	30,000
Act of August 2, 1882	30,000
Act of July 5, 1884	30,000
Act of August 5, 1886	33,750
Act of August 11, 1888	50,000
	213,750

AMOUNT EXPENDED TO JUNE 30, 1889.

The total amount expended in improving the entrance to Coos Bay to June 30, 1889, was $140,786.97.

RESULTS OBTAINED TO JUNE 30, 1889.

The jetty had been built to a total length of 1,761 feet, but a considerable portion of this consisted simply in a paving of heavy stone on the bottom in advance of the jetty, to prevent scour.

The results of the jetty thus far had been to keep the channel over the bar from varying its position as much as formerly, and to commence an erosion of the North Spit.

The bar-channel had been constantly improving since the commencement of work on the jetty.

AMOUNT EXPENDED DURING FISCAL YEAR ENDING JUNE 30, 1890.

Amount expended during fiscal year ending June 30, 1890, was $56,673.44.

RESULTS OBTAINED TO JUNE 30, 1890.

During the year there were placed on the jetty and jetty extension 38,845 cubic yards of stone, as measured on barges.

The result of dumping this mass of rock in what was formerly the mid-channel of the bay has been to cause a marked erosion of the North Spit, and to create a tendency on the part of the waters to break through the North Spit just below the end of the spit, which is above high water.

The channel is in a more northerly position than it was a year ago, and is somewhat shoaler, due to the fact that time enough has not elapsed for the currents to have scoured out a new channel under direction of the jetty. When the North Spit has become a little more eroded, and the direction of the channel straightened, it is hoped that the channel will deepen materially.

REPORT OF OPERATIONS FOR FISCAL YEAR ENDING JUNE 30, 1890.

Under contract of date February 6, 1889, Contractor O'Neil placed 38,845 cubic yards of stone in jetty. Borings were made on the North Spit and showed the material composing it was sand to a depth of 30 feet. A survey of the bar was made with the steamer *General Wright.*

A plan for the general improvement of the bar was submitted by a board of engineers. A survey of the present jetty was made and the notes plotted.

Search was made for the existence of Fearless Rock, so long shown on U. S. Coast Survey charts. The non-existence of this rock was demonstrated.

Vessel records were kept throughout the year, and the Government property watched and cared for.

RECOMMENDATIONS AND REMARKS.

Coos Bay is without question the best and most important harbor on the Oregon coast, excepting the Columbia River.

Its 24 square miles of tidal area, with its tides of 5 to 6 feet, give ample water supply, if properly directed, to establish and maintain a bar channel of at least 20 feet at least low-water depth, and 1,500 feet wide.

Borings indicate that the bar formation is entirely of movable sand, and that no rock exists to prevent the currents scouring a channel to the depth indicated, and even greater if their power be sufficient. The

existence of the littoral eddy current caused by Cape Arago, and observed by Captain Payson, will probably prevent any growth of the bar to seaward, and in this Coos Bay has a great advantage over any other harbor on the coast.

Cape Arago has an important bearing on the importance of Coos Bay for another reason, in that it furnishes shelter to vessels crossing the bar, and, laying outside the bar, from the worst storms of the year. The commencement of the southerly storms is usually from the southeast, and at such times the bar in its present position is sheltered by Cape Arago. The bar has often been crossed by steamers when conditions outside were unfavorable for immediate procedure on the voyage, they lying to under the cape. Here there is good anchorage, with from 40 to 60 feet of water. This jutting point of Cape Arago tends to make about the entrance to Coos Bay a veritable harbor of refuge during the prevalence of the worst storms of the year.

Coos Bay has also the advantage over many of the Pacific coast harbors in that one side of the harbor entrance is formed of solid enduring rock. This will render the application of the jetty system to the improvement of the harbor entrance cheaper and more certain of successful operation than if both sides of the harbor entrance were of sand.

The movements of sand in air and water about this harbor are very interesting and of vital importance to its preservation. The sand moves in a regular cycle, being washed up on the long North Spit, there dried, and taken up by the winds from the ocean and blown across the North Spit into the Bay. Here they accumulate in the water and form shoals, and are gradually washed down by the ebb currents to the harbor entrance and out upon the bar, to be again taken up by the ocean currents and carried northward and on to the ocean side of the North Spit to repeat the journey. It must be evident that if this cycle of events can be broken and the sand movement stopped the inside harbor will be greatly benefited, and the tendency of the harbor-bar channel to shoal up will be greatly lessened.

The place to break this cycle can only be on the spit, and this can be accomplished by constructions to arrest the movement of the sand across the Spit by the winds. A study of the best and most economical method of accomplishing this is recommended by the Board of Engineers, and the correspondence, translation, etc., herewith, in connection with the report of the Board, are submitted in furtherance of this therance of this recommendation.

This correspondence is convincing as to the fact that plant life can be established on the North Spit, which will, to a very great extent, if not entirely, arrest the sand movements, and that this will not be enormously expensive. It is estimated that there are 1,000 acres needing to be reclaimed, and that the cost of so doing will be $50 per acre.

The great and growing importance of Coos Bay is to some extent shown by the table of statistics herewith, showing the arrival of 354 vessels during the year, with a total tonnage of 117,726; an increase over the previous year of about 25 per cent.

It is extremely desirable that the Government should undertake at the earliest possible date and with the most liberal appropriations the construction of the work necessary to make of Coos Bay the best harbor possible.

There is tributary to Coos Bay an enormous forest area, the lumber from which, to reach the markets of the country and the world, should have an outlet to the sea for vessels drawing at least 20 feet. A harbor of this character would, it is estimated, give an additional value to this

lumber of about $1 per thousand feet. The county surveyor of Coos County estimates that in that county alone there are 7,500,000,000 feet of merchantable timber; this consists of fir, cedar, spruce, hemlock, myrtle, maple, ash, and alder.

The coal interests of the country about Coos Bay are very important. It is estimated that there are about 400 square miles of coal lands in Coos County. One mine only is being worked, and the output last year shipped out of the bay was 69,052 tons. This was shipped on steamers drawing between 14 and 15 feet of water, and the cost, I am informed, of shipping it to San Francisco was $3 per ton. If the harbor could be improved to permit vessels drawing 20 feet to engage in this trade the cost of freight would probably be diminished to about one half of this sum. This means a saving on the coal shipped this last year of about $100,000, but in the event of the improvement of the harbor and employment of larger vessels, other mines would be worked, and the output would be multiplied many times, and the aggregate benefit would be many times the amount named. But aside from the lumber and coal, and the agricultural, dairying, and other interests about Coos Bay, the improvement of this harbor will have a far-reaching effect on the whole of southern Oregon, especially of the portion west of the Cascade Mountains.

At present the rich valleys of the Coquille, the Umpqua, the Siuslaw, and the Upper Willamette have no market for their products and transportation of their imports except by the long railroad lines to Portland and San Francisco. This whole southern Oregon wants and badly needs a deep sea-port in its immediate vicinity readily reached by short lines of railroad. Coos Bay is the port towards which all eyes are turned, and on which the people of southern Oregon base their hopes. These lines of railroad are projected, and I am informed that work will be commenced on two of them within a very short time. One line leaves Roseburgh on the Oregon and California, and strikes southwest through Looking-glass and Camas valleys, and down the Middle Fork of the Coquille, via Myrtle Point and Coquille City, to Marshfield on Coos Bay. A second line leaves Drain's Station, on the Oregon and California, goes down Elk Creek to Elkton; thence down the Umpqua to its mouth; and thence down a few miles back from the coast to Glasgow, on Coos Bay.

A third line is expected to start from Eugene City or Springfield, tapping the upper part of the Willamette Valley, and run down the Siuslaw to Florence, near its mouth; thence to keep on south near the coast, and crossing the Umpqua, to make its terminus on Coos Bay, also at Glasgow.

The Oregon Improvement Company have started the construction of a railroad from Coos Bay to the Coquille, at the mouth of Beaver Slough, and still another is being located from a point known as East Marshfield, on Coos Bay, to the Coquille.

Regarding, as I do, the improvements of Coos Bay as of very great importance, second only to the improvement of the Columbia River and on the suposition that the report of the Board of Engineers of October 27, 1889, will be approved, I have the honor to recommend an appropriation of $750,000 for 1891–'92, to carry it into effect. I recommend this large sum in order that the work may be pushed forward and benefits derived from it as early as possible. The experience at the mouth of the Columbia shows the great importance and economy of making liberal appropriation for a work of this magnitude,

FUTURE OPERATIONS.

Assuming that the project recommended by the Board of Engineers October 27, 1889, or one similar, will be adopted, and that money for future work will be appropriated, it is expected that the operations in the near future will be the commencement of the jetty from the end of the North Spit.

Money statement.

July 1, 1889, amount available		$7,099.62
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$3,297.36	
July 1, 1890, outstanding liabilities	390.00	
		3,687.36
July 1, 1890, balance available		3,412.26
Amount appropriated by act of September 19, 1890		125,000.00
Amount available for fiscal year ending June 30, 1891		128,412.26
Amount (estimated) required for completion of project as recommended by Board of Engineers		2,341,412.20
Amount that can be profitably expended in fiscal year ending June 30, 1892		750,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. R. S. LITTLEFIELD, INSPECTOR.

EMPIRE CITY, OREGON, *June* 25, 1890.

CAPTAIN: Reporting the operations upon Coos Bay Improvement for the present fiscal year, work has been conducted under contract with Mr. P. O'Neil for a jetty extension of 300 feet, and to fill the old work as high as practicable with the barges used, which contract antedates the fiscal year and is to expire on August 1, 1890. Inclusive of date of this report there were dumped during the year on the jetty extension 33,615 cubic yards of stone, and on old work, to bring it to near half-tide height, 4,924 yards, or a total of 38,539 yards stone, as measured on barges at the work. This total, with the amount placed on the extension in May, 1889, 985 yards, has brought up the extension proposed from depths ranging 70 and 80 feet, end of old work, to 30 feet at extension end, to an average depth throughout, on crest of the extension, of 16 feet mean low water; besides a few loads stone were dumped on line in advance of the end to obviate scour.

The effect of the projection of such mass of stone toward the North Spit, opposite, is at this time very noticeable, for standing on it 600 yards above the line of jetty the bank of spit at low tide is nearly perpendicular, and the line of direction of the abrasion, or cutting, is almost directly on the first high projection of Coos Head, inside Coos Head Station proper, the part outside "Bluff."

The barges used, two in number, measure each on deck 29 by 90 feet, and carry their loads in pockets above deck, seven to each side, the floors of which have 45° slope. The stone is held in by perpendicular gates hinged on frame-work at top and secured below, or at the main deck, by chains, one to each gate, having a hook and ring attachment fastened to inside above deck frame-work. In dumping the ring is knocked off the hook, freeing the chain, and the practice is to drop the barge across the range for center line of the jetty, then against the tide, the barge being under slow motion, dump the pockets in pairs, as each comes directly on the line. A barge has been dumped in one minute, but everything working well the usual time taken is one to three minutes.

During the discharge of load the barge is kept in a position as nearly at a right angle as possible to the central line of jetty.

In bringing up the old wall the dumping mainly was done on flood tides, in the wall's growth, the barge really climbing it by aid of flood-tide swells, the tug towing facing the tide and letting the barge drop back as successive pockets in pairs were dumped, the dumping commencing at stern end of barge.

These barges are admirably adapted to the work in hand, as it would have been impossible to raise the wall with bottom dumpers on account of their draught, which

they must carry to instant of deposit of load, while on the contrary here the barge is lightened successively at end with the other end correspondingly brought lower, allowing the use of the word "climbing" as best descriptive of the process of raising the old part of jetty from inshore end of the 1880 crib-work out.

There are gaps at low tide left in the wall, about corresponding to the width of a barge, which can not be filled by the barges except on high or higher water than were taken. There has been considerable risk of damage to the plant on this part of the work, and damage did occur to the extent that one barge had to be hauled out for repairs, and of course there was more or less wear to the bottom planking of both barges by collision with rocks, grounding there, and the like.

The general plan of barge is the same as devised by Colonel Houston, Corps of Engineers, for dumping mud on shoal ground at improvements on the Great Lakes, and which lately has been adapted as a stone carrier on construction of the sea-wall, San Francisco.

As examined by a diver, the extension wall has steep side slopes, difficult to climb, and to quote him, "it looks hand-laid." There are trenches to both sides, 20 feet or more wide. On side down-stream, I found to-day 60 to 76 feet of water in the trench, the 76 feet about midway of the wall. On up-stream side, 52 to 60 feet, the 60 feet near end of wall but in a trench, and along beginning of the extension (up-stream side) 34 to 40 feet. Of course these are no greater than former depths, but the the ground now rises out of them, the trenches indicating sand deposit in neighborhood of the wall, above and below, which probably too has aided in building the wall.

For 80 feet in advance of any dumping there is now 6 feet average, deepening to the original bed.

Work has been prosecuted with vigor; the contractor carrying it on throughout the worst winter known here, only laying off 10 days, when the quarry-bed was under water; also his buildings uninhabitable, on account of the high freshet in Coos River, in forepart of February

The waters of the bay for over a month were colored by wash from the interior; the discoloration extending far seaward, and deposit may have tended to shoal Coos Bay Bar, especially it may have been so affected by the change constantly going on on bay side of the north spit, where the sand movement must be large.

The bar channel is in a more northerly position than it was a year ago, and consequently is shoaler, having 16 feet at mean high tide, as reported by Captain Magee, bar pilot. Delays to vessels have not been great, still they are more marked than for five years past. I would suggest that, following such a change as is being effected by the present extension to the jetty, time has to elapse for the re-establishment of a deep-water channel at the bar conformably to new conditions imposed, and that the outlet to the bay is not in its (for late years, since 1884–'85) undisturbed régime.

Respectfully submitted.

R. S. LITTLEFIELD.

Captain THOMAS W. SYMONS,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The following letter from Mr. Frank A. Stewart, collector of customs for the district of southern Oregon, with table of statistics compiled by him, exhibit the importance of the commercial interests of Coos Bay.

PORT OF COOS BAY, OREGON, *June* 21, 1890.

DEAR SIR: In response to your letter of May 29, I herewith transmit to you a general report of the domestic imports and exports shipped over the Coos Bay Bar during the fiscal year ending June 30, 1890.

Some of the minor data have been compiled from estimates in lieu of statistics, in which labor I have been generously assisted by the leading firms of the bay, and especially by G. W. Loggie, Patrick Flanagan, Hon. John Flanagan, Z. S. Siglin, R. J. Cussans, Benj. Barker, and J. Williams, of Wells-Fargo Express Company.

The more important items, viz, lumber, coal, number, tonnage, and class of vessels, etc., are absolutely reliable, while we all agree that the volume of business would greatly exceed the aggregates reported if it were possible to make a complete report.

Permit me to call your attention to the fact that there were for the year 81 more arrivals than during the preceding year. These arrivals represent a net tonnage increase of 18,734 tons over the previous year, and a corresponding increase in the volume of exports of $720,168.

Not only has the number of vessels increased, but there has been for many years a

steady increase in the size of vessels until for this year, the gross tonnage, which more nearly represents a vessel's carrying capacity, averages for each vessel 333 tons. This is directly attributable to the beneficial results of the Government work to improve the harbor.

This is a section of country of vast and varied resources, but partially developed, and there will undoubtedly be for the next year an output of products very much greater than this incomplete but splendid showing for the year just closed.

Very respectfully,

FRANK A. STEWART,
Collector of Customs, District of Southern Oregon.

Capt. THOMAS W. SYMONS,
Corps of Engineers, U. S. Army.

COMMERCIAL AND GENERAL STATISTICS.

The following returns, furnished by Mr. Frank A. Stewart, collector of customs, Empire City, Oregon, are for the year ending June 30, 1890:

	Number.	Net tonnage.	Gross tonnage.
Steam-vessels arrived coastwise	218	644.98	851.96
Sail-vessels arrived coastwise	136	246.90	325.30
Total	354	891.88	1,177.26
Inland river steamers on the bay (average length of routes 32 miles)	12	378.91	740
Number of passengers carried on bay, appoximate	38,500	.....	.....
Number of tugs and approximate tonnage	5	320.61	620
Total tonnage inland steamers	.....	699.52	1,360
Small tugs built and now running	2	58.37	116.74
Small inland steamers built and now running	2	30.14	60.28
Large schooners built and now running	1	451.40	475.14
Total tonnage and number built	5	540.91	552.17
Small steamers building (nearly completed)	2	50	100
Large schooner building (nearly completed)	1	626	675
Large steam-schooner building (nearly completed)	1	675	800
Small steamer building (nearly completed)	1	19	38
	5	1369	1613

Maximum draught of vessels during year, 15 feet 6 inches. The steamer-schooner *Tillamook* crossed the bar outward on June 14, 1890, drawing 14½ feet, and the schooner *Gardiner City* April, 1890, drawing 14 feet 10 inches.

No accidents on the bar during the year.

Coos Bay is in the collection district of southern Oregon. Empire City, on the bay, is the port of entry. The nearest light-house is at Cape Arago, on the south side, and west of the entrance.

Exports.

Articles.	Quantity.	Value.	Articles.	Quantity.	Value.
Coal ..... tons..	69,052.0	$486,364	Cheese ..... tons..	12.5	$5,000
Lumber (rough) ..... do...	124,479.0	647.190	Grain (wheat) ..... do...	20.0	500
Lumber (dressed) ..... do...	21,966.0	175,734	Hides (beef) ..... do...	48.2	5,850
Laths ..... do...	2,232.0	25,000	Logs (spruce)	.....	920
Staves	.....	27,000	Willow wood ..... tons..	18.7	750
Piles ..... tons..	1,340.0	10,000	Leather	.....	588
Match-wood ..... do..	3,730.0	49,000	Flag-poles	.....	1,250
Chittim bark ..... do...	378.0	75,600	Miscellaneous ..... tons..	429.0	33,500
Grape root ..... do...	5.0	600	Live stock (mules)	.....	500
Salmon (cases) ..... do...	463.5	81,692	Chickens	.....	300
Salmon (barrels) ..... do...	75.5	9,350	Coin, Wells-Fargo Express and otherwise, not postal	.....	350,000
Potatoes ..... do ..	31.2	875			
Apples ..... do...	32.2	1,080			
Butter ..... do...	10.0	3,600	Total exports .. tons..	224,329.1	1,992,903

Imports.

Articles.	Quantity.	Estimated value.
General merchandise ..... tons.	18,000	$900,000
Coin, Wells-Fargo and otherwise, not postal	.....	297,000
Total imports ..... tons.	18,000	1,175,000

LETTER OF MR. SHEDDEN F. WILSON.

PORTLAND, OREGON, *June* 18, 1890.

DEAR SIR: Owing to my absence from home I have only just received your favor of the 29th ultimo, asking information respecting the commerce of Coos Bay. Replying thereto I have now to say that the past year has been a prosperous one for this section of country. It has taken three steamers, averaging collectively about eleven round trips a month, to convey the output of the Newport coal mine to San Francisco, while the five saw-mills on the bay have kept a large fleet of sailing vessels and steam-schooners constantly employed.

In regard to the future, I will say that there is every prospect of our commerce more than doubling next year. The immediate building of a railroad connecting with the Southern Pacific at Roseburg is now a certainty. Work is to be commenced within thirty days, and the road completed and equipped by the end of next year. In addition to this we are promised in the near future a railroad from Drain to reach the bay by way of the Umpqua River and "Ten-mile" country; and also a road to come down the Siuslaw River and continue along the coast until it connects with the Donahue system in California.

All that is needed to make this one of the most prosperous places on the Pacific coast is an increase in the depth of water on our bar sufficient to allow of the ingress and egress to and from our harbor of a larger class of vessels. The money already so judiciously expended by the Government on the breakwater at the entrance to the bay has resulted in a marked improvement, and not only in the depth of water on the bar, but also in the straightening of the channel; and I think it has now been practically demonstrated that the completion of the work in accordance with the original plan will do for us fully as much, and probably more, than was claimed for it.

I have the honor to be, very respectfully, yours,

SHEDDEN F. WILSON.

Capt. THOMAS W. SYMONS,
Corps of Engineers, U. S. A.

REPORT OF BOARD OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, October 27, 1889.

SIR: The Board of Engineers, constituted by virtue of Special Orders No. 58, Headquarters Corps of Engineers, U. S. Army, Washington, D. C., October 26, 1888, for the purpose of considering and reporting upon projects for the improvement of Coos Bay and Yaquina Bay, Oregon, having reported fully upon the improvement deemed necessary for Yaquina Bay under date of November 13, 1888, and rendered a preliminary report upon Coos Bay under date of November 16, 1888, was by paragraph 1, Special Orders, No. 43, Headquarters Corps of Engineers, July 16, 1889, directed to reconvene at Coos Bay and Portland, Oregon, for a further consideration of the improvement necessary at Coos Bay.

Between August 24 and 27 all the members of the Board personally visited and examined Coos Bay and the bar at its entrance. On August 30 the Board met at Portland, Oregon, and proceeded to a careful consideration of the data at hand, furnished from this personal obser-

vation, by Captain Young, the officer in charge of the improvement in progress in this harbor, collected as suggested in the preliminary report of the Board and from the records of his office.

The Board now has the honor to report as follows:

HISTORY.

Surveys of the bar and bay were made in 1861 and 1885 by the U. S. Coast Survey. Another was made in January, 1880, by Capt. A. H. Payson, Corps of Engineers, for the Board of Engineers at that time investigating the question of a harbor of refuge on the Pacific coast. In 1879 a survey was made under the direction of Maj. John M. Wilson, Corps of Engineers, and in the same year a project for improvement was adopted.

This consisted in the construction of a half-tide jetty from near Fossil Point, inside the entrance, extending towards Coos Head on a slightly curved line. Work was carried on up to December, 1884, when a length of 1,825 feet from high-water line to the foot of the slope at the forward end had been placed. At this time the sum of $132,101.69 had been expended. The results of this construction have been beneficial in reducing the extreme curvatures of the outer channel and in giving increased depths inside in the vicinity of the work.

At its preliminary meeting, November 16, 1888, this Board took the following action in the matter, pending a careful study of the locality, which was necessarily deferred from various causes until September of this year:

The Board of Engineers, constituted by virtue of Special Orders, No. 58, Headquarters Corps of Egineers, U. S. Army, Washington, D. C., October 26, 1888, for the purpose of considering and reporting upon projects for the improvement of Coos Bay and Yaquina Bay, Oregon, having met as directed, at Portland, Oregon, proceeded to the consideration of the improvement of Coos Bay. After examining all available data bearing upon the subject it finds these insufficient to enable the members to arrive at definite conclusions as to the general project that should be adopted for the improvement of this harbor. Before making a visit to the locality and submitting a final report the Board has deemed it advisable to have additional surveys and examinations made and data collected.

These it has requested Captain Young, the officer in charge of the improvement of the harbor, to direct and have completed at as early a date as the weather and other circumstances will permit.

It is the design of the Board, as soon as the desired information is at hand, to reconvene, to visit the locality, and to mature a general project which it can recommend for adoption.

The beneficial effects of the jetty that has been constructed with the funds heretofore made available for the improvement of this harbor, and which it seems was originally of a tentative nature, have been so marked that the Board deem it advisable to make the following recommendations touching the disposition of the funds at present available.

First, that the bottom of the bay in the immediate front of the outer extremity of the jetty be paved in the same manner suggested by Captain Young in his project submitted to the Chief of Engineers, for the expenditure of these funds, but only for distance of about 200 feet; second, that the jetty as it now stands be raised to the level of low water, as far as practicable, by rock dumped from scows; and third, that the remainder of the funds be expended in the further extension of the present jetty raised to low-water level, along a line directed just outside of Coos Head.

The Board is of the opinion that this jetty is now of sufficient length to secure the results which may be expected to be attained by it, and hence simply makes the further recommendation that the bottom in advance of it be secured over such a length, not exceeding 300 feet, as will insure that its further action take place upon the spit instead of around its own immediate front.

DESCRIPTION OF THE LOCALITY.

Coos Bay is a tidal basin situated on the southern coast of Oregon, 200 miles south from the Columbia River, and 440 miles north from San Francisco. It is 75 miles distant from Roseburgh, on the Oregon and California Railroad, and about the same distance from Drain, on the same road, via the valley of the Umpqua River and the beach below the mouth of that river. The approaches on these two lines are by means of very poor roads crossing the Coast Mountains, which become almost impassable during the rainy season. The climate is characterized by a well-defined rainy season which extends through the late fall and winter months, during which there is considerable precipitation.

In this locality the Coast Range of mountains is composed almost entirely of great beds of soft argillaceous sandstone, which is extensively eroded by the numerous streams, and by the ocean waves at the numerous points where the ridges jut into the sea. The result of the erosion is an extraordinary quantity of fine quartz sand thrown into the sea to be cast up (1) opposite the points where inland tidal waters pass in and out through the shore-lines, forming bars, and (2) upon the beach, where the receding tide allows it to become sufficiently dry to be picked up by the landward winds of the warm season, thence to be carried up into the great reaches of dunes and low-lying spits which characterize the locality. The local peculiarity of these moving sands is simply that of unusual quantity.

Another feature to be observed is the dearth of harbors on this coast. From the mouth of the Columbia River to San Francisco, a distance of 640 miles, there is no harbor that will with safety and at all times accommodate the average sea-going ship drawing, say, 20 feet of water.

Storms of exceptional violence are rare, but in spite of this fact, the every day conditions of wave motion that have to be met by navigators entering and leaving port, and by engineers in exterior harbor constructions are those of considerable violence.

The surf is rarely at rest. Its normal condition is that of great activity. The great ocean waves that are constantly produced by the steadily prevailing trade winds, roll in on a steep, sloping shore, and are not tripped on the bottom until within a short distance from it. This produces a very heavy surf. It is sometines reported as breaking in 80 feet of water during violent weather.

The worst weather occurs during the winter months—say from November to April. Storms usually commence with the wind from the southeast, and thence veering around through the south and southwest to a clearing-off squall from the northwest. The bulk of the seas produced come in upon the shore from the southwest, the friction of the bottom holding back the shore end of the waves. During the warm season the winds blow pretty steadily from the northwest, and the seas then roll upon the shore from that direction.

The general trend of the shore is north and south. About 2 miles west-southwest from the Coos Bay entrance the headland known as Cape Arago projects into the sea in such a manner as to form an open harbor in the bend between it and the bay, which is well protected from all southerly weather. This point extends outward as a rocky shoal for a distance of about half a mile. The land extending from Coos Head, the south side of the Coos Bay entrance, to Cape Arago is high, generally covered with trees and brush, and presenting vertical cliffs of soft argillaceous sandstone directly upon the sea, with only a narrow beach exposed at low stages of the tide.

On the north side of the entrance to the bay the country is a mass of sand dunes, extending to the northward as far as the Umpqua River. Coos Bay proper runs for a distance of several miles to the northward behind a narrow peninsula of these dunes called the North Spit, and terminates after making a large bend inland in a series of sloughs, and Coos River, which brings in the drainage from the mountains. Another slough and a large one, called South Slough, comes in just east of the entrance and extends southward behind a high peninsula of sand-rock covered with trees and vegetation.

Certain noticeable facts are developed in the report of Captain Payson. (See Appendix 1.)

First. He observed the seas breaking in 8 and 10 fathoms of water.

Second. He observed the Kuro Siwo or Japan Current passing Cape Arago from north to south, approaching to or receding from the shore according to the prevailing winds. He also notes a distinct eddy current passing close by Cape Arago to the northward and past Coos Bay entrance.

Third. And bearing particularly upon the subject before this Board, he noted the peculiar action of the seas during the stormy weather, as they throw sand upon the northern extremity of the bar, thus forcing the channel across a more southerly line.

Fourth. His conclusions concerning the bight between Coos Bay and Cape Arago have not been verified. The survey of 1885 shows this bight to be extensively shoaling.

THE BAR.

In the usual manner the bar lies athwart the harbor throat on a line convex to the sea. This form is produced by the effluent waters, which tend to push away from the shore the sand cast up by the waves, and which also brings down to the bar the sediment which they carry from within. Commencing at Coos Head, on the south, it sweeps around over a distance of about 2 miles to the north, where it closes in upon the shore of the North Spit.

The waters from the tidal basin within have to pass in and out through the section along the crest of this bar. The sand composing it is sillicious, of very small grain, and hence easily moved. Just outside of Coos Head is an isolated rock, called Guano Rock.

The outer 4-fathom curve is slightly convex to the sea. The 5 fathom curve only slightly so, while the 6-fathom curve has substantially no convexity. In this connection is recalled the statement of Captain Payson that these curves have scarcely varied in position since 1861. These facts are significant. They indicate, though perhaps not with certainty, that beyond the 4-fathom curve the literal current is sufficiently strong to prevent deposition, and that all sediment from the Coos Bay Basin which is carried out that far is swept off to the northward.

The fact that the main portion of the bar lies to the northward of the harbor throat is an indication that the resultant movement of the sand along the outer face of the bar is northerly in direction. On the other hand, the observations on the ground show that the extremity of the North Spit, lying inside the bar, moves southward during the prevalence of summer winds. This accretion upon the submerged portion of the Spit may proceed from two causes: (1) The movement of sand along the beach produced by the breaking of waves coming in from the northwest, and (2) from the deposition of a portion of the sand from within, which has been blown into the bay from the North Spit. The fact

that the channel during summer gradually works around to the northward in spite of the influence of (1) would indicate that (2) was the more important factor.

Along its crest or line of minimum depths, the bar has a length of 2 miles. An examination of the section along this line, made in the summer of 1885, shows that the best water on the bar was 11 feet at low water, and this over a width not exceeding 100 feet, while the width over which there was 9 feet and more was over 4,000 feet. This is the ordinary condition in summer, and shows the great bulk of the water passing across the bar on nearly a north and south direction.

The bar is the result of drift and wave action, modified to some extent by the sands from the North Spit which have blown into the bay to be carried out by the ebb currents.

This locality has been under observation since 1861. During this time only one channel has been noted crossing the outer bar, but this has been extremely unstable in position. The observed history of the movement of the channel is substantially as follows:

During the prevalence of winter storms it makes across the bar near its southern end in the vicinity of Guano Rock. In this position it has had low-water depths of 20 feet. Captain Payson's observations show that this condition results partly from the peculiar action of the seas, sweeping around Cape Arago in such a way as to make a considerable deposition of sand on the north end of the bar, and at the same time leaving comparatively still water opposite the crossing at the south end. This peculiar condition disappears during the warm, dry season, during which the channel gradually swerves around to the northward.

The observed limit of the oscillations of the point where it crosses the crest of the bar is about 1 mile. The movement to the northward is slow and gradual, while that to the south is generally abrupt, sometimes taking place during a single storm. While the channel is in its southerly position the south end of the North Spit recedes, only to move back, however, as the channel across the bar thereafter moves northward.

The elements which operate to force the bar and channels have maintained a low-water channel at the gorge opposite Coos Head of 25,936 square feet area, with depths of from 40 to 50 feet.

Tidal observations as far as conducted indicate considerable abnormal action resulting from local conditions not sufficiently developed. The Board is of the opinion that full tidal record at stations extending to the head of the basin should be kept during the continuance of operations.

TIDAL CAPACITY.

A careful computation of the velocity and discharge elements of this harbor would involve such an assemblage of data from precise observation, as it is not practicable to obtain. The figures given below are only approximate in character, and are only given such weight in the discussion as they deserve.

The high-water area of Coos Bay, including the sloughs affected by tidal action is (from the U. S. Land Office surveys) 15,385.77 acres, or about 24 square miles. That of the North Bay is 10,631.5 acres, and of the South Slough 1,731.5 acres.

From a few observations Captain Payson reports the mean rise and fall of tide—

	Feet.
At Cape Arago light-house	5.26
At entrance to bay	4.69
At Empire City	3.59

From the above area and our best information as to tides the average outflow through the gorge section opposite Coos Head is estimated to be about 100,000 cubic feet per second. From this and the dimensions of the channel through the section it becomes apparent that the drainage waters of this basin, fresh and tidal, are sufficient when properly directed to maintain a much better bar entrance than has been habitually found.

Section at Coos Head (1885):		
Area at high water	square feet..	77,612
Area at low water	do...	25,936
Width at high water	feet...	5,830
Width at low water	do...	1,520
Wet perimeter low water	do...	3,200
Mean hydraulic radius, low water	do...	8
Greatest low-water depth	do...	49
Section along crest of bar (1885):		
Area at high water	square feet..	132,720
Area at low water	do...	77,610
Width at high water	feet..	10,800
Width at low water	do...	8,900
Wet perimeter, low water	do...	18,000
Mean hydraulic radius, low water	do...	4.3
Greatest low-water depth	do...	11

DRIFTING SANDS.

It is quite apparent that considerable quantities of sand are being carried from the North Spit into the bay by the winds of the dry season. As no recent survey has been made of this area, it is impossible to estimate precisely its effect up the bay. It may be presumed that such conditions of equilibrium between the incoming sand and the outgoing water have been established as to permit of the removal of a large part at least of this sand, to the outer bar and the spit inside.

The North Spit fronts on the bay, over a distance of about 7 miles, with widths varying from one-half to 1½ miles. It is a mass of light drifting sands, with a few scattering spots of vegetation. Beyond, to the northward, the sand-dunes stretch in a straight line as far as the mouth of the Umpqua. The influence of this sand is seriously injurious in two ways: (1) by its tendency to fill up the bay and reduce the tidal compartment; and (2) by giving the forces operating on the outer bar the unnecessary work of handling and disposing of a large quantity of sand. It may be observed here that during the winter or rainy season the sands on the spit are too wet to be moved by the wind to any extent, and the relief thus afforded to the outflowing water may be a factor in the production of the improved channel that is usually found at that season. The Board is of the opinion that it will be found practicable to restrain the movement of sands at least in great part. It does not, however, recommend specific measures to that end at present. The engineer in charge ought, however, to study this matter carefully, with the view to adoption of economical methods which shall serve to eliminate this vexatious element.

PROJECT.

On the Coos Head Section, or the habor throat, the hydraulic radius at low water is 8 feet, with a surface width of 1,540 feet. This is attended with maximum depths of over 40 feet. Hence, if we confine the channel between high-tide jetties, spaced 1,500 feet apart, extending

from the shores seaward, we ought thereby to develop a jetty channel having nearly the same conditions.

The bar channel, lying seaward of the western end of the jetties, must be expected to have a less depth.

It is the opinion of the Board, formed by study and comparison of this and other Pacific coast harbors, that the ruling low-water bar depth thus developed ought to be at least 20 feet. Adding the rise of tide, the usual high-water depth becomes about 25 feet.

The Board therefore proposes two jetties, crossing the crest of the bar in parallel lines, at a distance apart of 1,500 feet, and otherwise located as shown on the chart herewith—a north jetty resting on the south end of the north spit and a south jetty resting on Coos Head. Both jetties to be of riprap stone laid as far as practicable on mattresses 3 or 4 feet thick and rising to high water.

The axis of the jetty channel is projected to pass through a point 500 feet north of Guano Rock, with a direction N. 60° W. The mass of the jetties in deep water, say up to low-water line, may preferably be made of stone of small dimension where not exposed to violent wave action; in the latter case they should be made of stone sufficiently large to resist such action. It will be preferable to bring the whole mass of the jetties in deep water, to about the level of low water before building any portion above that level.

It is a result of experience that as increased depths are secured larger waves enter the channel and attack the jetties by undermining the sandy foundation upon which they rest. On the outer or seaward sides the jetties are protected by accumulated sands and are not exposed to serious dangers; but it is quite the contrary on the channel side. It is therefore a part of the project to extend from both jetties groins on the channel side of not less than 100 feet in length, spaced at intervals as may be determined by circumstances. The object of groins is to promote deposition of sand along the channel sides of the jetty, in this way securing stability of the work.

The jetties are to be brought fully to the level of the highest tides; they are to be built of riprap stone, deposited generally from a tramway on mattresses of brush.

The width on top is 10 feet, with natural slopes on the outside, and such wave slope on the inside as may be developed. This is assumed in the estimate as two base to one height.

Stone is found abundantly about 24 miles distant, with water communication, and it is estimated that it can be placed on the work at $3 per ton or $4.50 per cubic yard, including in this plant tramways, brush, and all other accessories.

In view of extraordinary and unforeseen circumstances likely to occur on the sea-coast, it is thought advisable to add to the estimate 20 per cent. for contingent expenses.

ESTIMATE.

North jetty:		
Length	feet..	9,600
284,886 cubic yards riprap at $4.50		$1,281,987
South jetty:		
Length	feet..	4,200
171,857 cubic yards riprap at $4.50		$773,350.50
Total for both jetties		2,055,343.50
Contingencies, 20 per cent		411,068.70
Total		2,466,412.20

COMMERCIAL STATISTICS.

Coos Bay is in the collection district of southern Oregon. Empire City, on the bay, is the port of entry. The nearest light-house is at Cape Arago, on the south side and west of the entrance.

The following returns furnished by Mr. John Flanagan, collector of customs, Coos Bay, are for the year ending June 30, 1889:

Number of vessels, steam, arrived coastwise	149
Number of sail vessels arrived coastwise	122
Total	271
Number of steam-vessels cleared coastwise	147
Number of sail vessels cleared coastwise	126
Total	273
Registered tonnage of steam-vessels arrived	46,162.60
Registered tonnage of sail-vessels arrived	25,292.94
Registered tonnage of steam-vessels cleared	46,147.54
Registered tonnage of sail-vessels cleared	25,262.95
Number of vessels built, 2; registered tonnage	1,028.73

Exports.

Articles.	Quantity.	Value.	Articles.	Quantity.	Value.
Coal ..... tons..	44,850	$313,950	Salt salmon ..... pounds..	650	$6,500
Lumber, rough .... ft. B. M..	36,309,400	363,094	Salmon ..... cases..	5,000	26,250
Lumber, dressed ..... do...	9,077,600	145,241	Potatoes ..... tons..	15	300
Staves ..... bundles..	13,000	19,500	Apples ..... boxes..	1,000	600
Laths ..... number .	6,000,000	15,000	Butter ..... pounds..	20,000	5,000
Piles ..... feet, linear..	80,000	4,800	Cheese ..... do....	31,000	4,650
Ship knees ..... number..	300	1,500	Beef hides ..... number..	1,600	4,800
Match wood ..... cords..	1,200	8,400			
Chittim bark ..... tons..	35	3,500	Total value of exports.		923,585
Oregon grape-root. pounds..	5,000	500			

Imports.

General merchandise	$450,000
Farm implements, machinery, and railroad iron	30,000
Total value of imports	480,000
Number of passengers arrived by sea	864
Number of passengers departed by sea	720

The draught of the vessels trading to Coos Bay, when loaded, varies from 13 feet to 14 feet 10 inches.

The principal exports are lumber and coal; hops, wheat, oats, salmon, leather, and hides are also among the exports.

The imports consist of general merchandise and machinery.

No foreign vessels have been entered, nor have any duties been collected at this port during the year.

Very respectfully, your obedient servants,

G. H. MENDELL,
Colonel, Corps of Engineers.
W. A. JONES,
Major of Engineers.
THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

EXTRACTS FROM REPORT OF CAPTAIN A. H. PAYSON, CORPS OF ENGINEERS.

U. S. ENGINEER OFFICE,
San Francisco, Cal., January 8, 1880.

COLONEL:

* * * * * * *

From the northwestern point of the high land known as Cape Gregory or Arago, the coast line extends east northeast for 2 miles to Coos Head, the southern point of the entrance to Coos Bay. Opposite the head and some 5,000 feet away, is a low, sandy point, from which a beach, backed by high and shifting sand dunes, runs nearly due north magnetic for 20 miles to the mouth of the Umpqua.

These two stretches of coast line, lying thus nearly at right angles to each other, form in the bight between them the only considerable southerly shelter which can be found from San Francisco to Puget Sound.

Just off the northwest point of the Cape, and separated from it by a rocky channel, nearly dry at low water, is an island, with almost vertical sides, rising from 40 to 50 feet above the sea and about 350 yards in length, from north to south. At its southern end it is from 300 to 400 feet in width and covered with trees; thence it dwindles, suddenly, to a very narrow spine or ridge, in places almost breached by the action of the sea, with the light-house on its outermost or northern point.

Beyond the light is another high, but bare, rocky islet, and beyond this again three others,, over which the sea breaks at high water, the outer one of all being 1,800 feet from the light tower itself.

Beyond this outer rock, on the prolongation of the reef, the bottom is rocky and uneven, with a depth of from 5 to 7 fathoms, for 1,300 feet, when we come to a ledge in from 3 to 4 fathoms, and this has on its northern edge a sharp pinnacle rock, covered by only 11 feet at low water, with seven fathoms directly outside of it. This is, virtually, the end of the reef, but it can be further traced in the 10-fathom contour by a well marked ridge, rising from 8 to 20 feet above the general level of the bottom.

The general direction of this line of islets and the ridge is a well preserved, straight line, bearing northwest, by compass. The material of which they and the main shores to Coos Head are formed is a very soft sand-rock, which can be readily cut with a knife or hatchet, and would be perfectly worthless for building purposes.

The cliffs it forms are nearly vertical and peculiarly cut and worn by the sea.

Eastward from Light-House Island, some 4,000 feet, is Yokam Point. The shore between keeps the general height of the island, with a narrow strip of sand beach, bare at low water only, at the base of the cliff, while from the top a barren prairie, grown with fern, slopes up for about a third of a mile to the edge of the woods.

The point itself is higher and forms several jagged projections, from the end of one of which stretches a line of five rocks awash, the outermost 1,400 feet from the shore, and their general direction parallel to that of Light-house Reef.

East of Yokam for 400 feet more the shore is lower, with woods just back, and a broad sand beach in front; while thence to Coos Head high cliffs rise directly from the sea and are covered to the edge with a dense growth of timber and underbrush.

An examination of the coast north of Coos Head furnished ample evidence of a large movement of the sand southward, under the influence of the summer northwest winds, which, though not equal in violence to the winter gales in the opposite direction, are yet so steady during most of the year that their effect is much the more important one.

The dunes, back of the beach, some of which are 150 feet in height, show this movement in their form with sharp slopes to leeward, and from the crest of each on any summer day may be seen blown out a long trail of flying sand.

Large tracts to the north of Coos Bay and along the neck separating its lower part from the sea, where once stood farms and pine forests, are now buried to the tops of the highest trees.

Immense quantities of this wind-borne sand are constantly going into the bay and by its swift currents carried out to form the bar or be deposited in the bight to the east and north of the cape.

The seas caused by the northwest winds striking the coast at a slight angle also throw large quantities into suspension, to be carried away by the ocean currents in which they find themselves.

From these circumstances and the position of the bight at Arago, we might suppose that there would be a tendency for it to become shoaler, at any rate during the season of summer winds. Whether or not this is the case we have no means of knowing, but it can be shown that if this tendency exists at all it is temporary in its effects and corrected by the winter storms.

The Coast Survey chart of Coos Bay entrance is from work done in 1861, which included an examination of the approaches.

Though the latter was not in detail, it enables us to fix, with tolerable accuracy, the position at that time of the 3, 5, 10, and 12 fathom contours.

On the tracing sent herewith the curves for these depths for the two years are plotted over each other.

Considering that the plane of reference in 1879 was probably a foot lower than in 1881, the coincidence of the 10 and 12 fathom lines, separated as they are by an interval of eighteen years, is almost perfect, while between those at 3 and 5 fathoms, though they are compared only in the neighborhood of the shifting-channel entrance, the difference is small, and the advantage in depth on the side of the later survey.

In this connection another fact becomes significant:

South of the light for 3 or 4 miles the shore is a high sandstone cliff, rising directly from the sea, while below this we come to another beach, stretching nearly to Cape Blanco, behind which the inland and southerly progress of the sand dunes is even more extensive and noticeable than that before referred to north of Arago.

This large movement of sand in the same direction on both sides of that cape, taken with the lack of any appreciable change in the bay to the north of it, is a reason for concluding that all this material must be carried past by the prevailing ocean currents.

The main ocean current, which is a part of the general circulation in the Pacific, runs constantly to the south, at varying distances from the shore.

Under the influence of northwest winds it closely approaches the principal headlands, and is notably increased in velocity; while by the southerly storms it is sometimes reversed, probably only at the surface, and in both directions causes contrary eddy currents in the bights close along the shore. Since the northwest winds are the more constant and effective agent, these eddies are generally to the northward, and their effect is plainly shown in the tendency of the outlets to many if not most of the small rivers and lagoons to work in the same direction.

The existence during the greater part of the year of such an eddy in the bay north of Arago might almost be presumed from its position and the foregoing facts; but there is other testimony to the same effect.

First. The southerly coast set is well marked close in to Cape Arago headland. I have found it a knot an hour during calm weather a quarter of a mile off the light, while during heavy northwest winds it is well known that vessels making the cape close in are often obliged to stand offshore from two to six hours before they can weather.

Second. The Coos Bay tugs tow also on the Umpqua Bar, and I was told by their masters that in their frequent trips to and fro they have found that they can make better time by going up close inshore and coming down farther off; and this is not to get alee, since the coast-line is perfectly straight.

Third. In September, 1878, the lumber-loaded schooner *Phil Sheridan* was abandoned off the mouth of the Umpqua, having been in collision with a steamer. The waterlogged wreck was towed by a Coos Bay tug inside Cape Arago and left there on account of the roughness of the bar. It was afterwards seen close in to the beach and several miles north of the entrance, having drifted there, I was told, against a strong north wind.

The weather at the place is so generally bad for hydrographic work, and the very slack currents in the bight so masked and complicated by the tides of Coos Bay, that a long series of current observations would be necessary to obtain any precise information.

These observations I had no chance to make, but the following facts were noted:

First. At the outer-bar buoy, shown on chart 7, the set was south and off the land during flow and ebb.

Second. Along the beach, from the light to Coos Head, the set was offshore and to the eastward on several occasions when I was able to observe it.

Third. During both flood and ebb I have noticed a set in through the light-house reef.

Fourth. During smooth weather an eddy-line of floating kelp and drift can almost always be seen stretching north and east from the same.

Finally the north winds blow in such a way into the bight as to probably create by themselves a current along its southern shore to the eastward.

* * * * * * *

The channel out of Coos Bay is subject to large and rapid changes; its exists to deep water in extreme positions being separated from 1½ to 2 miles, and its main directions shifting from east and west to north and south; while its least depth has ranged from 9 to 20 feet.

These changes are incessantly in progress; more gradual and in one direction during northwest weather; sudden and in the opposite during winter gales. After every period of rough weather the pilots, before towing in or out, are obliged to make a careful search for the existing channel, previous knowledge being entirely untrustworthy.

The ruling depths will also change from 2 to 3 feet in a single storm. Under these circumstances, in spite of the service of efficient tugs, the delays to commerce are great and unavoidable; schooners having been kept inside, waiting for a chance to cross for three and four months and steamers for thirty days.

At the time of my examination the bar channel was in position at its most unfavorable extreme.

From the low point on the north and Coos Head on the south side of the entrance, stretch two submerged sand-spits, overlapping each other, and defining the channel.

By the inner, or north spit, this is kept in a narrow and deep passage close against the rocky eastern shore of the lower bay and the clifts just inside Coos Head.

By the outer, or south spit, it is then deflected sharply back in almost the opposite direction, and running north by west along the outer face of the north spit, for nearly a mile and a half, crosses the crest of the bar and comes abruptly into deep water. Though the least depth is 14 feet, it is found in a very narrow space; the distance between 3 fathom curves inside and out is more than a mile, and the direction is unfavorable with respect to wind and sea.

A reference to the tracing, on which are compared the entrances in 1861 and 1879, shows that in the former year the ends of both spits were cut away. The channel was out to the southward in a more favorable direction, and the distance by it between 3-fathom curves was only half a mile.

At times, again, the channel has broken through the northern part of the north spit, leaving a large shoal to the north of it, and gone straight out to sea close under Coos Head and on both sides of Guano Rock.

When this takes place the water is deepest (I was told by the pilots that in this position they have had 20 feet at low water in the channel), the distance between 3-fathom curves least, and vessels can sail in or out with the prevailing winds.

In this southernmost position the whole ebb is projected normally against the opposing sand ridge, and therefore cuts its way through in the deepest and straightest line; while with the channel as in 1879 the first of the ebb escapes uselessly over the spits, and the rest uses much of its force in the sharp bend it is made to follow.

The history of these changes will be about as follows:

Suppose the channel out in the southern position close to Coos Head in the beginning of summer, a south spit at once begins to form, and by its prolongation and the wearing away of the outer side of the north spit the channel works steadily and gradually northward.

This movement continues until the first heavy southerly gale, the effect of which will be to cut away the ends of both spits, and send the channel entrance south, to a greater or less degree, depending on its violence, duration, and the state of the tides. The storm over, the northerly movement recommences, and so on for perhaps a number of years, until some gale of extraordinary force and length, coming with a course of spring tides, breaks the channel out again where we have supposed it at the outset, and one cycle of its changes is completed.

The forces normally in action through the greater part of the year tend always to force the entrance northward, while the violent, but intermittent, effort of the southerly storms arrests or undoes their work.

I have given the reasons for believing in the existence most of the time of an eddy current north past the entrance to Coos Bay.

If there is such a current it would seem to furnish a sufficient cause for the northward movement of the channel over the bar.

Considering the apparent absence of any other agency competent to produce this effect, and the fact that it is felt during the season of northern winds, when the eddy is most likely to be found, the movement itself might be taken as an additional reason for inferring the existence of so natural and adequate a cause.

An examination on the spot will convince one that the original entrance to Coos Bay was opposite North Bend; that the present eastern or inner shore was the ocean beach, and that the sand in its progress south, under the influence of summer winds, has gradually formed the tongue, which now lies between the lower bay and sea.

Further progress has been checked by the rocky headland, which stretches from Coos Head to the light, but the same causes being still in action, tend to lengthen this tongue and the inner or north spit.

For this reason the favorable change which takes place when the channel breaks out through the upper end of the spit can never be a permanent one.

The sand is at once thrown across the new passage, and the ebb, instead of being discharged at right angles to the crest of the bar, is forced against the lower shore of the bay into the mouth of South Slough and against the cliffs inside of Coos Head. * * *

It remains to assign a reason for the fact that the entrance from deep water outside to the channel shifts south in heavy southerly gales, the channel itself becoming thereby straighter and deeper.

During such weather the sea often breaks so heavily across the entrance that the

tide, for some time, can not run out, and the surface level of the bay becomes backed up from 2 to 3 feet above that of highest springs.

This pressure may increase to such a point that the pent-up water breaks out along the line of least resistance, and that is close along the shore by Coos Head, through the base of the south spit.

This is plain to the eye when the line of breakers is in from 8 to 10 fathoms. At such times the seas swing around the tip of the cape, until they come upon the contours of those depths, break heavily across and into the ordinary northern entrance to the bar channel, leaving that space close along the shore from Coos Head to the Light comparatively smooth and sheltered.

And, generally, when the sea becomes much heavier than usual, the line of breakers, instead of closely following the shore and spits, swings out across the bight, and, while directly opposing the exit of the tide by its usual course, forms a natural breakwater for the shelter of that corner in which the south spit lies.

This is narrower and not much higher than the bottom of the so-called channel; hence it yields readily to any increased pressure brought upon it. Any cut through the south spit is always accompanied by a corresponding modification of the north and it is remarkable how quickly both show the tendencies above described during any southerly storm.

After a week, during last October, when the bar was impassable, I have seen the inner spit cut away for fully 400 feet to a depth of three fathoms and the channel entrance through the outer shifted half a mile to the southward. * * *

In connection with the possible improvement of the entrance, the question whether Coos Bay itself has been filling up since it was first known becomes of much importance.

Judging from the eye alone this would appear to have been the case, since extensive and newly formed banks, bare at low water, can be seen in several places, while near North Bend high sand hills seem to be advancing bodily into the bay.

The interested character of available testimony and the fact that, while filling may be visible, favorable change can only be shown by a general survey make it impossible, without one, to definitely decide this question. * * *

The tidal observations in the upper bay were made in the hope, that the time of transmission of the tidal phase from point to point might show the existence of some well marked obstruction to its passage.

On reducing and studying them however, it is found that the rate betweeen th same stations varied in such an irregular and extraordinary way, for different tides, that they could be made to furnish no general principle whatever. For instance: High water in the mouth of South Slough being one day, one hour, fifteen minutes later than at the light, another is sixteen minutes earlier. Between Empire City and North Bend the time varies from fifteen minutes to an hour and fifteen minutes, and so on for all.

This is probably due to the many large sloughs, which have their outlet in the bay and empty and fill in different times under different circumstances of wind and weather.

The high water being earlier at South Slough than at the light, as was several times the case, seems to indicate that it had begun to ebb in the slough while it was yet flood in the lower bay, and that the water level was thereby backed up at the staff.

And generally the apparent acceleration of the phase at high water, up stream, looks as though the last of an incoming tide was met by the first of the ebb from some of the numerous bay tributaries. The effect of the bar is shown in the fact that while the average rise and fall at the light is 5.26 feet, at South Slough it is only 4.69 feet, at Empire City it is 3.59 feet, at North Bend 3.60 feet, and at Marshfield 3.79 feet. * * *

COL. C. S. STEWART,
Corps of Engineers, U. S. A.

RECLAMATION OF SAND DUNES.

PORTLAND, OREGON, *November* 14, 1888.

SIR: The Board of Engineers now in session, in considering the improvement of the harbor entrance at Coos Bay, finds itself in need of further information, which it requests you to procure at as early a date as you find practicable, as follows:

First. A hydrographic survey of the lower bay, particularly with a view to show changes in depth that have occurred above and below the

groin now partially constructed. About a half mile of channel above the groin is suggested for survey.

Second. It is desired to learn whether the new position of channel near and opposite the end of the groin is underlaid by unscourable material, or otherwise.

Third. The board regards, under its present information, the movement of sand by wind from north to south on the peninsula as an important feature affecting the improvement. It is desired that a study of this be made with a view to arresting or controlling the movement, if this be found practicable.

Fourth. A map showing the tidal area of the bay is desired. If such a map is not in existence, exhibiting both high and submerged bordering land, you are requested, if you find it possible at small cost, to prepare, from land surveys or other reliable information, a map or sketch which shall be at least approximate in outline and description.

The Board will probably meet for further consideration of the subject before it in the spring, perhaps in March and April, by the time this information is procured.

Very respectfully, your obedient servant,

G. H. MENDELL,
Colonel, President of Board.

Capt. WILLARD YOUNG,
Corps of Engineers, U. S. A.

LETTER OF CAPT. WILLARD YOUNG, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, August 17, 1889.

COLONEL: In compliance with the instructions contained in your letter of November 14, 1888, a survey of Lower Coos Bay, in the vicinity of the jetty, was made during the months of January and February, 1889. A map embodying the results of this survey was subsequently prepared and is submitted herewith. For the purposes of comparison there are also submitted maps of the surveys of 1878, 1879, and 1885.

In order to determine whether the new position of the channel near and opposite the end of the jetty is underlaid by unscourable material or not, borings were made for several hundred feet across the north spit, on the line of the proposed jetty extension, and also for several hundred feet along the inner line of the spit, and to depths ranging from 20 feet to 30 feet. The location and depths of these borings are shown on the 1889 map herewith. So far as determined the spit is composed of sand to the depth of at least 20 feet below low water.

It was found after repeated trials that hand power would not suffice for pumping down the gas-pipe used as a boring tool. A steam-boat with powerful pumps was therefore chartered at considerable expense to furnish the necessary power. With the appliances then available, it was found that at a distance of 600 feet from the pumps a depth of 20 feet only could be attained.

To have extended the borings further than was done would have involved an expense greater than was thought justifiable.

Regarding the movement of sand by wind from north to south on the peninsula, I have to state that in my opinion it is possible to arrest and control this movement by the methods generally used for reclaiming sand dunes. The cost would be something like $50 per acre, and per-

haps 3,000 acres would have to be reclaimed to prevent the sand from drifting into any part of the bay.

The lower bay from about a mile above the jetty downward is the part most needing protection from drifting sands. This could be given by the reclamation of about 1,000 acres of sand dunes.

For the methods usually employed in the reclamation of sand dunes reference is respectfully invited to the following works submitted herewith:

Notice sur les dunes de la Coubre, par M. De Vasselot de Regne.
Biennial Report of the San Francisco Park Commissioners, 1872-'73.

A map showing the tidal area of Coos Bay in its different compartments has been prepared from land office surveys and is submitted herewith.

Very respectfully, your obedient servant,

W. YOUNG,
Captain of Engineers.

Col. G. H. MENDELL,
Corps of Engineers, U. S. A.,
President of the Board.

A.—EXTRACTS FROM THE FRENCH WORK, "LES DUNES DE LA COUBRE," PAR M. DE VASSELOT DE REGNE.

Although the whole mass of sand composing a dune may be entirely removed under the action of the wind, the transportation is effected grain by grain; that is, the top grains are first rolled away by the wind, and those next underneath coming to the surface are carried away in their turn, and so on.

Therefore, if the grains on the surface are held in position, there is nothing to fear from those that are underneath, and the whole down is rendered immovable.

The whole system of fixation or reclamation of sand dunes depends on this fact. A temporary immobility may be obtained by covering the soil with branches and boughs, but care must be taken to arrange the brush-wood in such a manner that the strongest winds will respect this cover, at least as a whole.

With the protection thus afforded, which will last as long as the cover used, the plant seeds will germinate, the plants will take root, and a living plot will take the place of the covering. In order that the work may not be buried by the neighboring movable sands, care must be taken to establish the first frames parallel to the shore, upon the part comprised between the sea-beach and the downs nearest to the sea. In this way nothing is to be feared from the masses previously accumulated and in movement towards the land.

The frames will advance closely on each other from year to year, in long parallel zones or bands, laid without any interruption, and the work of an epoch, never threatened by the existing movable downs which the wind pushes in an opposite direction, will be protected besides by all the previous works, against the invasion of sands which the sea will continue to deposit on the shore. By means of special works, the new deposits of sand will themselves be retained, diked, and held near the coast; instead of invading the young seed beds they will form a bulwark between them and the spray of the sea, and soon the wilderness will be replaced by handsome and productive forests. * * * When the reclamation of the downs is undertaken, the seed beds run a first and very great danger, that of being covered again, either by the neighboring movable sands which the wind displaces or by those which the sea brings in.

It is necessary to retain near the shore, as soon as they arrive, the sands which the ocean throws up, otherwise the reclamation of the downs would be impossible, since the work that may have been executed would sooner or later be buried under new beds of sand; while on the other hand, the sands already accumulated can be held in place only by the successive execution of the work.

It is therefore necessary to conduct the operations in such a way that the work shall never be on the road of the movable mounds already formed, and that the works of one year shall always be secured by those of the previous year.

Upon an unindented coast this plan is easily carried out by establishing the first frame-work as near as possible to the sea-beach line upon which the sand is depos-

ited, and each one of the others to the landward of the preceding, which it must touch throughout its whole length.

In this way the frame-work of the first year is liable to be covered up only by the new deposits which are to be held in place; then it protects the second, which could be reached only after completely burying the first.

The third frame-work is fastened to the second, and so on; each new task being secured in this way by the work of previous years; the seed beds adjoining each other, and starting from the shore, they follow the downs in the direction of their march, and finally cover them completely. * * *

The littoral down is the first construction created by hand, to be met with in localities where the ocean brings in sand. It is formed in the following manner:

Upon the flat adjoining the sea-beach a palisade is constructed parallel to the water line and distant from it 200 meters. The palisade is made of boards about 8 inches wide, and separated from each other by intervals of about $1\frac{1}{8}$ inches.

When the sand thrown up by the sea is carried away by the wind it strikes against this obstacle and accumulates at its base; then, under the effect of its own weight, it passes slowly through the intervals left for this purpose, or, so to speak, strains through the fence, and deposits it simultaneously on both sides. Then a mound is formed, and the board is gradually covered up by the sand.

The watchman and his helpers raise the boards, regulate the work of the wind, which is not very regular in its way of operating, close up the gap, and place new material about the parts undermined.

These phenomena are renewed, and a literal hill composed by the sand stopped on the spot (and whose volume is estimated upon an average, on the coast of France, at 25 cubic meters per running meter of shorel) gradually rises between the ocean and the downs to be sown, forming itself a protecting shelter against the sea winds.

* * * * * * *

In place of board palisades, or jointly with them, fascines are frequently employed composed of stakes from 5 to 8 feet in length, from 2 inches to 3 inches in diameter at the middle, driven into the sand 20 inches and placed at intervals of 20 inches. These stakes are afterwards woven together about 20 inches above the ground, either with brush from 5 to $6\frac{1}{2}$ feet long placed end to end, or with marsh grass rolled in rope shape and about 4 inches in diameter. When this first woven work of brush is nearly covered up with the sands which it stops, a second fascine woven-work 20 inches high is put on, and the work isrepeated in the same way as fast as the sand is brought in until the woven-work reaches the top of the stakes. Then the stakes are raised with clawed hand-spikes, and the same work is then recommenced.

In raising the fences after they are covered up with sand, it is necessary to consider the most favorable form to be given to the mass of sand stopped. It may be conceived that gentle slopes are less easily uncovered than steep ones, and that they can be more easily covered with vegetation; but, on the other hand, they offer a less sufficient shelter.

After weighing all these merits it was concluded to adopt as the most beneficial profile for the littoral downs of the Coubre, a trapezium having a very gentle slope on the sea-side; that is, a slope of from 5 to 8 base to 1 perpendicular, then a level strip of greater or less width, and a steep talus on the plantation side.

In this way the hill or dune presents a surface but little exposed to strong winds, and by reason of its height gives to the plantations the best possible shelter.

To give this form to the deposits, tufts of reeds or fagots of brushwood are placed in front of the palisade in quincunx order, in narrow bands, the total width of which is kept equal to eight times the height of the obstacle opposed to the circulation of the sand. The number of tufts composing these bands is successively reduced one-half as the bands are further removed from the palisade.

Thus these tufts widely separated upon the line where the sand is to begin to take the declivity of the littoral down, hold there a small quantity of sand. Placed nearer and nearer together as they approach the palisades, they stop more and more sand, and graduate the amount retained as far as the palisade itself, where the maximum effect is reached. This arrangement causes the progressive stopping of larger or smaller volumes of sand, in proportion to the nearness of the tufts, and determines immediately the slope which the deposits are to have.

It is necessary, of course, that the intelligence of the man in charge of the work should be exercised. He will place these tufts at greater or less distances apart, according to the raising of the ground, and if necessary, he will use different sized tufts.

If the shore presents natural heights, he will build them up only after the neighboring parts shall have reached the same level.

When the palisade is buried with sand it is raised, and the plantation of reed is extended to the sea-side, so that the width of the planted zone is always eight times the height of the obstacle after being built up, and in such a way that the zone al-

ways occupies a width equal to that of the surface upon which the accumulation must be produced, a necessary condition to obtain the desired slope.

It is well that the reeds planted in the winter season should have at least one bunch of roots, because often in this case they shoot and become living plants. Seeds of this same reed can be sown between these tufts, or sea-wheat, armisia, sea-kakila, salt-wort, horse-tail, or any other sea-weed may be used. If there is no reed, it should be replaced by armisia or by brushwood, or little fagots of twigs 20 inches in circumference, from 15 to 23 inches long, which should be arranged in the same order that the reed would have been. Care is also taken to place some spurs perpendicular to the palisade, and separated by an interval equal to once and a-half times their length.

Often in order to save money, labor, or material, the spurs are used without covering the intervals with brushwood or tufts, and their presence in many causes suffices to obtain the result wished for.

It ordinarily becomes necessary to provide them with counter-spurs, made of vertical boughs in the places where the sand seems to find difficulty in accumulating, to finish them in goose-foot shape, in order to prevent the excavation which the winds would make at their ends, and to change their location once or twice during the formation of the littoral down.

If the palisades are not frequently raised, when the deposits are abundant, the sand completely covers up the boards. Afterwards the wind, striking a slope steeper than those that are generally formed under its action, turns up the sand and makes it pass onto the other side of the sunken boards. The slope toward the sea is worn, and becomes more and more hollow and steep, and when the wind blows normally to the palisade, the sand torn from the down, or coming from the shore, re-ascends this slope with a great speed, and by reason of this acquired speed it continues to follow an ascending direction to a certain height; after having passed the summit, it appears like a smoke in the air, and is thrown over onto the other side.

The boards are thus excavated on the sea-side end; give way by sections, and breaks are formed in the down; such is the habitual origin of the cuts ordinarily oblique and known under the name of "wind whistlers," which always tend to enlarge more and more, and which it is difficult to fill up. The stopping of the sand in the "wind whistlers" is accomplished by means of fences made of standing boughs, and of plantations of tufts in quinounx order, as described above in connection with the littoral palisade.

Sometimes the wind, blowing in a direction oblique or parallel to the palisade, uncovers the boards, by excavating little by little a kind of a ditch. The boards then fall if they are not covered again with shoveled sand. The breaches produced in this way are followed by the same consequences as those before spoken of. It is well to observe, however, that this effect is to be feared only from the board palisades, and has never been noticed with the fascine works made of stakes, tied together in the manner above described. On the other hand, these latter seem to be more liable to excavation on the sea slope, but in the end it is easier to avoid breaches with them and to raise a regular down. * * *

But in raising the barriers without ever thinking of anything else than the care of the summit and the avoiding of cuts, the sand soon produces steep slopes on each side, and the result is to get a thin down, in knife-blade shape, where, as the breaches are much more difficult to avoid, the height becomes greater; then, in order to give to these mounds the profile adopted as a type, spurs made of stakes are constructed perpendicular to the palisades, 100 meters apart and 66 meters long. The tops are arranged with care so as to form a straight line in full sight from the starting point at the height of the palisade stakes to the other end, and one meter above the level of the shore; so the workmen have only to fence as the sand arrives to be sure to have the deposit in a regular slope.

To these spurs have been added counter-spurs, made of vertical boughs, at the places where the sand was most wanted.

This operation has been successful above all expectations, and to such an extent that excavations 6 meters and more in depth have been filled in less than a year.

The downs are thus supported by powerful stiffeners, and can resist storms. If as these long spurs are buried under the sands which they accumulate, new ones are placed in the middle of the intervals of stiffeners that they form, no doubt but that a perfect consolidation will be promptly obtained, and that there will soon be a shelter as well established at its base as it is regular in its upper part; and with the protection of these first works, nothing need be feared from sand deposits for the next works, whatever they may be.

The works of reclamation, so called, consists in the putting in order of the covers and the spreading of seeds upon the ground; this is the way to proceed.

A first task is laid out to the windward of the movable masses whose invasion is feared; it is generally either along side of a littoral palisade, or at the landward side of a valley (that will be protected afterwards) that the works are begun.

This first frame-work consists of a zone or band 300 meters wide, and variable in length, according to the work to be done, and to the disposable resources for the campaign. If natural obstacles are found, such as mounds, meadows, or watery depressions, they will be utilized to meet the end of the delineated work. Otherwise, each end will be closed by a palisade of defilement, so called; this line must be as nearly parallel as possible to the direction of the dangerous winds which might drive some sand to it. In this way the lateral invasion will be avoided.

Between this task and the balance of the downs a flying palisade will be established to protect it against the return of the sands moving under the influence of the land winds. * * *

The work begins on the side of the flying palisade. Along that line a band of 5 meters wide is left bare and uncultivated; for if there were seed plots on this space they would soon be covered by the sands filtering through the palisade, under the influence of winds opposed to those that determine the general motion of the downs, and as a consequence they would soon be lost.

Therefore, a parallel to the flying palisade is marked out, at 5 meters distance, which becomes the head line of the frame-work. Children distribute the fagots at 2 meters apart upon the ground, parallel to that line, over a length in meters equal to twice the number of persons who must work in building the cover, and move towards the other limit, that serves as a base to the frame-work. For instance, if fifty persons are employed in covering the ground, the task will have an extension of 100 meters, and the distribution of the fagots will be made closely one after another, over the surface produced by a moving line 100 meters long, and distant at first five meters from the flying palisades, backward parallel to itself until it joins on the other side of the frame-work base line.

When the width of the surface upon which the fagots are distributed reaches about 20 meters, counted from the frame-work front, seed is spread on this space at random, in the same manner that wheat is sown in the fields.

This seed is composed for two acres of—

	Kilograms.
Marin pine	30
Whin	3
Broom shrub	3
Reed	3
Various seeds to attract the birds destroying the insects	3

Then the frame-work party, stationed in rank near the flying palisade, is put to work. The bindings of the fagots are broken, and they are spread with the big ends of the branches turned toward the sea and the twigs of the following row covering the big ends of the row previously laid on the ground. The arrangement of the boughs is therefore similar to that of roof tiles. The men lift big shovelfuls of sand, taken from the portion upon which the cover is not yet laid, and put them upon the spread twigs. These shovelfuls are about 2 feet apart, measured from their centers, and suffice to hold the covers in place. The gang thus work backwards; during this time children continue the arrangement of fagots behind the workmen, and the seedsmen, while directing the gang, see that there is always ground sown ready to receive the cover.

When the ground is covered in this way, as far as the palisade, or as far as the base line, the workmen move to the frame-work front and commence again a new section contiguous to the preceding one, and they continue in the same way, taking care to prolong the flying palisade, in order to always protect the piles of material always necessarily preceding the works of which they are the principal element.

If mounds, with sharp tops surmounted with reed tufts, are found in the way, as frequently happens near the flats, the reed stems are lopped off and the surfaces rounded before the sowing, otherwise the boughs could not be laid closely together upon the ground.

Since 1872 this system has been improved upon in certain points in the following way:

Straight parallel lines, at distances of 10 feet apart, are traced perpendicular to the flying palisade. A strip 2 feet wide and 16 inches deep is dug out along each one of these lines with a hoe. A seed brush or drill following the middle, the furrow thus hoed out is opened, seed is sown in it, a pulverent manure is spread upon the seed, about a quart to the running meter, a light coat of sand is put upon the manure, and the ground of the drill is pressed down, either with the foot or otherwise. Two other drills are traced and placed at 1 foot to the right and left of the middle one, when seed is put in one and broom shrub in the other, they are treated in the same manner as the first, and the whole is strongly covered with the best brushwood laid with this end in view along these cultivated strips, at the time of laying the fagots upon the ground. The interval between the drills is also sown and covered as in the spots where furrows were not dug, and the whole of the work is done simultaneously. * * *

The task of each year extends section by section, in long bands parallel to the zone, sown in the preceding year, of which it is thus the continuation; and as we have already said, it is protected by a flying palisade against the return invasion of the sands of the down, until all the mass is covered.

When each new section joins onto the seed plots previously executed, the flying palisade between them becomes useless and is taken away, since there is no movable sand on either side of this barrier.

The boards of this old line of projection are utilized for the extension of the new flying palisade, therefore, in a word, during each campaign, a new palisade is not built, but the one built in the first place is successively transported to the front of the new frame-works.

As it is not possible to stop a seed plot in the middle of a steep slope (since the works executed in the high portion would soon give away) it is customary, when there is one found in the direction of the flying palisade used as a front to the frame-work, to deviate the line in order that the slope may be sown as far as its base. The frame-work is a little larger in this place, but as soon as the ground permits it, the extension of the head-line is established in the direction previously determined, and the working field takes again its normal width.

The sowing is begun about the month of October and is stopped in the month of May. * * *

Two kinds of damages are to be feared; the sand and its cover of branches may be carried away by the wind from certain parts of the surface. This is seldom the case when the cover is well made. It is necessary then to fill up these uncovered portions, known under the name of air-holes, put seed in again and recover the ground. A vegetation as vigorous as that of the surrounding parts is hardly ever obtained on these parts.

The sand may sometimes recover a zone of seed plots more or less extensive by coming in from the flank or by drifting over the tops of the supporting palisade. In this case it suffices to cover the ground a second time with brushwood and to sow again the invaded surface, and the portions thus reclaimed have always an exceptionally fine vegetation.

In la Coubre a surface of 5,150.65 acres has been reclaimed by the system above described. The cost was $142,503.19, or about $27.50 per acre.

B.—LETTER ON THE SUBJECT FROM THE SECRETARY OF AGRICULTURE.

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., February 3, 1890.

SIR: I have the honor to acknowledge the receipt of a letter of the Chief of Engineers, referred to this Department, and making inquiry if any experiments in the interior have been made with forms of vegetation which would indicate successful results if applied to the work of reclaiming the sand downs on the sea-coast.

In reply I would say that this Department has made no experiments especially with such a purpose, but the botanist would respectfully state some observations bearing on the subject, to wit:

Near our Experiment Station in southern Kansas the sand downs which prevail in the vicinity of the Arkansas River have been during a few years past. very much stayed and fixed by the growth of a very strong, deep-rooted grass which, although itself not nutritious, serves to bind the sand and give opportunity for the growth of better species.

Similar results are said to have been attained with a much stiffer and stronger grass, (botanically *Ammophila arundinacca*) at Cape Cod, Massachusetts, an account of which is given in Flint's Grasses and Forage Plants. This grass is also used in planting on the dikes of Holland for the same purpose.

Respectfully,

J. M. RUSK,
Secretary.

HON. REDFIELD PROCTOR,
Secretary of War.

C.—REPORT OF THE ENGINEER UPON THE MANAGEMENT OF SAND DOWNS, WITH AN ACCOUNT OF THE EXPERIMENTS CONDUCTED AT GOLDEN GATE PARK, AND SUGGESTIONS FOR THE PROSECUTION OF THE WORK OF RECLAMATION THERE CONTEMPLATED.

OFFICE OF THE ENGINEER TO THE PARK COMMISSION.

GENTLEMEN: In accordance with your instructions, I have investigated the subject of reclaiming shifting sand downs, and caused experiments and observations to be made upon the sands at Golden Gate Park, and as the result of these studies, I have the honor to submit the following report:

RECLAMATION OF SAND DOWNS.

From the date of the agitation of the matter of a park for San Francisco the locality since chosen for its site became the subject of unintentional misrepresentation caused by a general want of knowledge concerning the management of drifting sands. Not long since, the assertion that any vegetation would thrive on these shifting downs in their natural state would have met an incredulous reception. But in older countries, where the present state of agricultural science combines, the results of many years of experience with careful observation, as in the sea-coast division of Europe, or even in newly settled lands, where matters so nearly connected with the general welfare are placed in scientific hands for development, as in Australia, the public mind would have been earlier enlightened upon this subject, and there would not have been such uncalled for assertions as have been made to the detriment of the present Park Reservation.

Thus, at its commencement, the improvement of the site as a pleasure ground, was greatly hampered by an underestimate of its capabilities, and an exaggerated idea of the probable cost of the work, arising from the general idea that all the land was situated upon the shifting downs, and a misconception of the nature of the works necessary for their development.

The fact that 270 acres of the reservation embraced a tract susceptible of being made pleasurable in a marked degree by the construction of a few miles of carriage road, was entirely overlooked, as well as the difficulty of cultivating the other portion, upon the downs, overestimated.

In the abstract matter of reclaiming shifting sands by plantation there is no lack of precedent; the landes of France, the polders of Holland, and the heaths of Denmark have all been the scenes of operations of this kind, extending over thousands of acres, each of which has been marked of late years by the most signal success; while equally gratifying results have been obtained upon portions of a vast sand drift on the Baltic sea-board of Prussia, at various points on the coasts of England and Ireland, and the Europeon shores of the Mediterranean.

These several works, carried on as they have been under various conditions of climate and through long series of years, were originally projected upon many different plans and prosecuted by the employment of numerous engineering expedients, and the use of a great variety of vegetation. So that the adoption of one particular method or plant has been at times recommended here by the representatives of the one country, while other means have found advocates in those who have happened to notice their efficacy in some other locality.

The question, then, has not been, "Can these sand hills be covered with verdure?" but "Which of the methods heretofore employed is most applicable in this case?" or, "Are there other means at hand likely to produce as good or even better results?"

Hence it is that by a consideration of the means used elsewhere, as well as a careful study of the characteristics of the case in hand, a just appreciation of its bearings is to be arrived at and a comprehensive scheme devised for its management.

The improvement of sea-board sand downs may be classed under two distinct departments of work, namely, arresting the sands brought upon the beach by the ocean waves, which operation must result in the final stoppage of all advance from this source of supply, and the holding of the already drifted sand of the downs themselves with the production of vegetable growth thereon.

In the prosecution of the earlier experiments of which there is any record in this field, the former division was regarded as a purely engineering work and the latter was left to agricultural resources alone.

Thus such expedients as heavy artificial bulkheads and sea-walls were resorted to, with a view to accomplishing the first end; while the simple sowing of seeds, which were left to the mercy of the winds, was made use of to attain the last-named purpose the one class of improvement involving enormous expense and attended with but partial success, the other resulting in total failure.

The two arts mentioned then combined their efforts; engineering being assisted by agriculture, and lending a helping hand in return; each still preserving a predomi-

nant influence in its own department; both endeavoring to guide the energies of nature, rather than oppose them, and the result has been a complete success.

Man, as the director, with the forces of nature as laborers in the field, now readily converts these wandering hillocks into fixed and productive features of topography.

The engineering works of constructing barriers against the sea were modified to mere banks of sand, erected by the winds and waves themselves, under man's guidance, bound together by the matted roots of plants which were found to thrive thereon and but slightly protected on the water slope by some artificial means, while the growth of vegetation upon the downs was facilitated by a series of protecting palisades or layers of fascine coverings.

Of the two departments of work, that to be performed upon the beach is the most important; for it is found that the source of supply being cut off, the sands of the shifting downs gradually become clothed with vegetation by spontaneous growth; while on the contrary a constant and unchecked deposit of sand upon the beach, by its drifting over, will totally defeat any attempt at cultivation upon the downs.

The engineering expedients resorted to in both departments of sand-down reclamation have varied greatly with the changing circumstances under which such works have been prosecuted.

The agricultural operations are confined to the simple propagation of plants from roots, cuttings, and seeds upon them.

Without referring at all to botanical arrangements, the plants best adapted to cultivation on sand downs may be divided into two classes, of which the first embraces those trees and shrubs which have very long tap roots diving deep into the body of the formation, as it were, for sustenance. The second embodies such grasses and creeping or spreading plants as throw out numbers of interlacing, fibrous roots, persist in pushing their tops above the drift which may cover them, root afresh at every joint so covered, and thus build up a hillock throughout whose bulk their ramifying rootlets extend for themselves. The plants of the former class will not admit of much sand being drifted over them, and therefore as well as for other reasons, are suited to plantation on the body of the downs where the shifting of the surface sands is to be immediately stopped. Those of the latter class will not flourish to their fullest extent unless there is a constant fresh supply of the silicious particles blown upon them, and are consequently best adapted to the beach works.

In the annals of down reclamation, two names stand forth prominently as those of organizers of successful experiment. Bremontier, an engineer of public works in France, was the first person who systematically pursued the cultivation of tap-rooted plants upon sand downs. His labors were prosecuted on the shores of the Gulf of Gascony, in 1787, and several succeeding years. About the same time the Danish Government, under the administratron of Reventlov, instituted a well-considered scheme of planting the second class of plants for the reclamation of the sands of Jutland, which succeeded. And thus Reventlov is accredited with their introduction, although Linnaeous, the great naturalist, first suggested the employment of the principal plant of this class (*A. arenaria*) for the purpose, and although they had been previously used in Holland to some extent, as auxiliaries of engineering expedients in consolidating the dikes of sand.

SAND-DOWNS OF FRANCE.

The downs of the Gulf of Gascony, embraced by the departments of the Gironde and the Landes, extend from the mouth of the Adour to that of the Garonne, a distance of 150 miles, and have an average breadth, inland from the sea-shore, of 3½ miles, covering an area of about 300,000 acres. Their extreme height is 330 to 350 feet, which elevation is reached near their inland border, about midway of the belt, where it attains the greatest breadth, namely, 5 miles. The advance of these sands has been variously estimated at from 15 to 60 feet per year, and had been going on for ages, covering up whole districts of farming land and entire villages.

Many futile attempts had been made at various points to stay the progress of this all-devouring monster by individual inhabitants of the districts, by municipal and provincial authorities, but all without success. In 1780 Government aid was invoked, after repeated complaints of the threatened communities. Nothing was done, however, until 1787, when M. Bromontier, at that time chief engineer of the department of the Gironde, commenced a series of experiments with a view to establishing practically the tenability of his theory, which was substantially that nature could be able to clothe the downs with verdure if properly guided by art.

He proposed to sow the downs with seeds of pine, broom, and furze, and prevent the drifting of the sand temporarily by artificial means, such as low woven fences, or light coverings of brush, until the young plants springing therefrom would be large enough to protect themselves and the sands also.

The management of drifting sands had been attempted upon the coast of Holland and along the shore of Denmark, as well as at some points on the border of the Brit-

ish Isles, but no success had been achieved by any plan which depended for its accomplishment upon the vegetable growth which the sand itself was capable of sustaining. All the methods employed involved such heavy expense for artificial works in the way of bulkheads to resist the action of the waves at the beach, or coverings and fertilizers to check the drift and facilitate growth on the downs themselves, that their use was only justified where some more important object than the reclamation of the sands was in view, such as the preservation of harbor or river channels, or the protection of valuable lands which the sands threatened to cover.

Bremontier made a scientific study of his subject, observed the action of the waves on the beach in bringing up the sand, and watched the phenomena of its transportation inland to the utmost limit of the belt. He noticed the movements of the sand itself, the formation into dunes, and their progress. He demonstrated the presence of moisture the year round sufficiently near the surface of the sands to sustain vegetable life and even promote luxuriant growth in suitable plants. He examined the under soil of a district in the neighborhood, which was already clothed in a dense forest, and whose configuration of surface led him to believe was of dune origin, and finding it almost pure silicious sand, his suspicions being confirmed, he argued, and correctly, too, that the same vegetation would thrive on the then shifting dunes if the action of the winds on the surface sands could be stayed for a sufficient time to allow young plants to become well rooted. He also studied the behavior and disposition of sand when opposed in its progress by obstacles of various descriptions, and determined the proper character of hedges or fences which should be used to stay its progress. Thus fortified, in the year above mentioned, the "great engineer," as the chronicler repeatedly calls him, made the first plantations along the shore of the gulf in the neighborhood of the old forest of La Teste.

The work was carried on at intervals until 1793, when it was abandoned for want of funds.

In 1795 a committee of citizens, appointed by the directorate of the department of Gironde, made an examination of these plantations and reported upon their condition in the following terms:

"There exists at present no further doubt about the complete success of the reclamation of the downs; one can not without astonishment behold the beauty and the vigor of the vegetation in the plantations. We find there a great number of pines, seven years old, that are from 18 to 20 feet high; willow plants, four years old, grown from cuttings or slips, which have this year thrown out shoots 9 feet long, not counting the growth which they will yet make before the fall of their leaves; young oaks, arbutus, furze, etc., all growing as vigorously as in the best soil of the Republic."

In a report presented to the administration of the department of the Gironde in 1790 Bremontier gave at length his plans for prosecuting the reclamation of the downs, proposing various methods for arresting the drift of the sands for the first three years, which time it was supposed would be sufficient for the plants to develop. His schemes were all in the main successful, so that the inhabitants of the district he so greatly benefited afterwards erected a monument to his memory near the site of the original plantations. Subsequently the great work was taken up again and has been prosecuted steadily but slowly, until more than 232,000 of the 300,000 acres are now under cultivation.

Further investigation and continued experiment under the various engineers in charge of the downs have from time to time suggested modifications of Bremontier's plans, but his fundamental ideas are still embodied in them all. Thus M. Goury demonstrated the fact that upon the highest inland dunes, where the texture of the sand was finest, from the greater mobility of such small particles, enabling them to outstrip their coarser companions in the race before the winds—perpetual moisture was presented at a depth of 4 inches under the surface, while near the shore, on the lower dunes and in the valleys, where the sand was coarser, and owing to its consequent diminished capillary power, the line of moisture was a foot below it. It was found thus feasible to adopt a less expensive character of shelter on these high dunes, and a great saving was effected.

DOWNS OF DENMARK.

Nearly the entire sea-board of Schleswig-Holstein and the western coast of Denmark is covered with what was a few years ago drifting sand. The "sand-sledge" (mat grass) has affected the reclamation of over two-thirds of the 190,000 acres which this drift is estimated to contain, and forests of trees are now becoming prominent features where but a few years ago the sands advanced unchecked.

DOWNS OF PRUSSIA.

A great portion of the Baltic coast of Prussia is covered by dune sands. This formation, which is called the Pomeranian downs, after the sea-board province of that name,

although of comparative recent origin, embraces an area of more than 50,000 acres. The works carried on for its reclamation were very poorly conducted for many years and resulted in repeated failures. Under the direction of a systematized management, however, their conversion into forests of fir and birch trees and grass-covered meadows has been most successfully carried on for the past seventy years.

DOWNS OF HOLLAND.

Nearly the entire length of the sea-board of the Netherlands is a sand formation, which attains a width in some instances of 5 miles.

These downs are regarded as a blessing to the country, since they act as natural ramparts against the terrible storm floods which sometimes set upon the coast from the sea, thus protecting the lower lands from inundation. By proper management they have been made, as elsewhere explained, in some instances to answer the purpose of the very costly artificial dikes for which that country is noted, and in many other cases they have greatly facilitated the construction of these latter.

The Holland downs are estimated to cover an area of 140,000 acres, of which over 100,000 acres are held by plantations of the "Helm" (mat grass) and "Longstraw" (lyme grass). The rearing of trees upon these downs has but lately been commenced to any great extent, yet the larch, willow, pine, and fir are found upon several tracts of many acres in extent.

SANDS OF GREAT BRITAIN.

There is no estimate of the extent of down formation on the coast of Great Britain, but there are reliable statistics of the reclamation of several tracts of drifting sands, amounting to some thousands of acres, by the use of the "Marum" (mat grass) and "Bent" grass herein described.

THE SAN FRANCISCO SAND-DOWNS.

Compared with these great European sand wastes the San Francisco downs seem insignificant indeed. Covering an area of only 3,000 acres they are exceeded seventeen times by those of Prussia. They are as one to forty-seven to the Polders of Holland. The Klittens of Denmark are sixty-three times as large, while the Landes of France cover an area one hundred times their extent.

The San Francisco sands resemble those of France very closely, their component parts being principally silicious particles much rolled and rounded, with iron, a small percentage of mica and calcareous fragments—the latter the débris of shells—the residue being for the most part soluble earthy matter, in which latter constituent they are richer than those of any of the great deposits of Europe, of which a record is at hand.

The rate of advancement of these sands, determined by a comparison of their present limit with those fixed by survey at periods eighteen, seven, and four years ago, respectively, has been 39 feet per year from 1855 to 1866; 42 feet per year from 1866 to 1870; and 45½ feet per year from 1870 to and including 1873. The increase in this rate of late years is probably not due to any augmentation of the amount of sand brought upon the beach, but to the fact that as the dunes advance up the slope of the peninsula their sands spread over its surface in a thinner layer, and, as a given quantity of sand is blown forward each year, it covers the greater width of firm earth from the fact of its being to a less depth.

OBSERVATIONS UPON THE SAN FRANCISCO DOWNS.

A study of the details of the several reclamations alluded to, and an investigation of the circumstances under which each had been prosecuted, made the necessity of attention to the characteristics presented in this case more apparent and served to point out the advisability of scrutinizing the material provided by nature which might be made available upon the work here contemplated. Such a study was made, and it need hardly be said with encouraging results. For instance, it was found that, (1) most of the phenomena of the development of, and conditions in, sand-down formations which had entered as important factors in the arrangement of the details of reclamations elsewhere, were found to exist in a more or less marked degree upon the San Francisco downs, with other circumstances apparently peculiar to this latter locality; (2) the sands of the San Francisco downs closely resemble in composition those of the Gulf of Gascony, in France, and are markedly different from those in Holland and Denmark; (3) the line of permanent moisture in the San Francisco downs, although at a lower level than is recorded of this phenomenon in the European sand formation, rises closest to the surface wherever a covering of vegetation is affected; (4) climatic conditions, likely to exert an important bearing

upon the development of vegetation on the sands, are very different from those of any of the European countries mentioned as the scenes of similar works. With some of the characteristics of the climate of southern England, and a similarity in other features to that of France, the San Francisco climate embodies the long drought of summer and the substitution of a rainy season for a frozen winter, which establishes a near resemblance to a portion of Australia, yet still exempt from the great heat of the latter country; (5) the natural vegetation upon and in the neighborhood of those downs established the fact of the fertility of the sands composing them, and a closer examination of this vegetation seemed to indicate a direct provision of nature for their reclamation. Thus, it was noticed that, wherever the drifting of the sand was checked for a short period, a spontaneous growth of natural herbage made its appearance. And, again, along the edges of the downs, whenever certain of these plants became partially covered by the advancing sands, they appeared to freshen up with remarkably vigorous and healthy appearance, spreading over the drift and battling with it until overwhelmed.

It was therefore to be concluded that, (1) the engineering appliances used elsewhere for the management of drifting sands would be equally efficient here, but that their use would be regulated by the character of the material at hand; (2) the plants proven to be adapted to sand-down culture in France would be more applicable to the main portion of the San Francisco work than others which had produced equally good results in Holland, Denmark, or Prussia, while those recommended for such use in Australia were likely to be of still greater adaptability here; (3) whatever final benefits might reasonably be expected from the cultivation of foreign vegetation, no better results could be attained in the primary matter of stopping the drift than those probably to be afforded by the use of native plants; and, furthermore, that the growth of some of these seemed to be such as to warrant expectations of the most complete success.

It was also ascertained that these means were not altogether untried, that under the direction of an enterprising owner of a portion of this sand-drift the problem had been in a measure solved.

EXPERIMENTS AT GOLDEN GATE PARK.

To demonstrate on an appreciable scale that the sand downs could be held, and covered with vegetation, however homely, by these most simple and economical means without going into any more extended line of experiments, involving future outlay for maintenance, the means for which it was not certain would be at command, now seemed to be the most expedient course. Accordingly in December, 1872, and January, 1873, a trial plantation was made.

Considering the immediate object, as above stated, of this experiment, choice was made of the stronger growing of the native plants, namely, two members of the Lupine family (*Lupinus arboreus* and *Lupinus albifrons*, Bolander), although there are others likely to produce more acceptable landscape effects. The yellow lupine of this climate is a hardy, perennial, half-shrubbery plant, attaining a height of 4 or 5 feet, and covering an area equivalent to that of a circle 6 to 8 feet in diameter. It lives to be three or four years old, bearing seeds abundantly after the first year. The blue lupine is a much smaller plant, seldom attaining more than half the dimensions above mentioned. It dies at the end of its second or third year, having produced but few seeds. These are tap-rooted plants, and to be classed in this respect with those used by Bremontier in France.

The circumstances that, in making heavy cuttings through old sand formations in the park, their roots were in several instances traced to depths exceeding 25 feet, the bushes themselves not being over 3 feet high, constituted the strongest proof that these plants would be suitable for cultivation on the downs; which, with the fact of their remarkable rapid germination and growth from seed, and the facility with which the seeds could be gathered, made up a good recommendation of them as sand-heath plants.

Several members of the Lupine family, *Lupinus albus* particularly, have been extensively grown in Germany and France, where their tops when young are used for cattle fodder, and their seed fed to poultry. They have also been cultivated on poor, sandy soils to be turned under as green manure; but never before used for the purpose of reclaiming drifting sea sands in the way here applied.

Tap-rooted plants, to be extensively employed in sand reclamation, must be propagated upon the downs themselves from seed; their success depending upon the progress of the leading root which penetrates far into the sand before the top much more than shows itself. Lupine seed, therefore, was gathered and sown. For the reason above given, also all plants which succeed upon loose sands develop very slowly at first, while they are becoming well rooted; which fact had been the cause of the failure of early attempts at reclamation in Europe, the young plants being overwhelmed by the drift before they were large enough to hold the sands; and to prevent this was the object

of the protective measures, before alluded to, which were afterwards adopted, constituting a large share of the expense of reclamation in that country. Thus it would probably take the young lupine two months to develop from seed sufficiently to protect itself; so it was imperative that it be, in the meanwhile, shielded. Common barley, which sprouts from the seed on the fifth day and attains a height sufficient to hold the drift on the twelfth day after planting, was sown with the lupine for this purpose.

In order to still further test undecided points involved in this reclamation problem, some seeds of the *Acacia lophantha* (which tree had been recommended for the purpose) and of the Maritime pine (the tree so successfully employed in France) were sown at the same time.

The result has been: The barley, as was expected, protected the lupine while very young and effectually prevented all drift of the planted ground throughout the storms of winter and spring. The lupine has covered the surface of the plantation with a nearly dense vegetation 2 or 3 feet high in a single year. The acacia seed produced fine young plants, a few of which have lived through the summer, but most all were killed by a succession of heavy frosts, which occurred some time after they came up. The pine seed, not being very fresh, did not produce more than half the plants which it should have produced. Of these many were burned up by the heat of the sun, and others suffered from proximity to the lupine, which, being a greedy plant, deprived them of sustenance; so that but few have lived throughout the summer, but those are now doing well.

This experiment, with further observation and research, affords data upon which to base conclusions as to adaptability to cultivate here of the various plants mentioned in the annexed list, as set forth under each title, but the chief results are as follows:

The San Francisco downs can be covered with a shrubby vegetation resembling that upon the older sand-hills of the neighborhood, in which the lupines are prominent features, without fail, at a very small expense, and in a period of less than two years.

The hills may then be converted into forests of thriving young trees, conifers principally, while the valleys may be covered with grass the year round and grouped with another class of young trees, all of which will grow without irrigation.

PROPOSED WORK OF RECLAMATION.

From the foregoing a programme for the proposed work may be deduced as follows:

(1) The erection of a coast dune, or bulkhead of sand, as it were, after the fashion of some of the Holland dikes and similar works in other European countries, by causing the sand, which is brought upon the beach by the waves, to be piled up by the winds (as described under the head of the "Great Highway"); the bulkhead to be consolidated by means of the grasses indicated in the appended list as suitable to the purpose, and finally improved further, as illustrated under the same heading.

(2) The reclamation of the drifting sands by the native vegetation, with such of the imported as may seem suitable.

(3) The plantation of the dunes with seeds and plants of trees, as enumerated in the list.

RESULTS WHICH MAY BE ANTICIPATED.

It may reasonably be anticipated that the following recited ends will be attained:

(1) The stoppage of all advance of sand inland from the beach during the second year of the work.

(2) The conversion of the downs into heaths covered with native vegetation during the first year of the work.

(3) Their presenting the general appearance of a young forest of evergreens at the end of the sixth year; which, affording shelter and shade with quite a variety of foliage in its several exposures, and open glades in the valleys, will have a decided park-like aspect about the twelfth year after the commencement of the work. After the first year the portion of this district within the park may be rendered pleasurable to the public by the construction of drives and rides, which from the peculiar features of topography traversed will be especially attractive.

COST OF RECLAMATION.

The cost of sowing and maintaining the young forest of the French downs, exclusive of the works of protection at the beach, wasduring the first years of reclamation about $13.50 per acre. Of late years, owing to the advance in price of good seed and labor, the cost has been about $20 per acre. The cost of planting the grass upon the beach was about $11 per acre and is now estimated at $14 per acre. The cost of reclama-

tion by the use of grasses, in Denmark, has ranged from $10 to $15 per acre; and in Holland the expense has been somewhat less for the plantations.

The cost of erecting and maintaining protective dunes, or dikes, varies greatly, as to the degree of exposure to which the work is to be subjected, and the situation of the land to be protected (whether above or below flood tide level) necessitates a greater or less expensive character of engineering work. In Holland, these embankments are very substantial, being generally built and protected by artificial means, and only overgrown by grasses planted after their erection; but on the sandy shores of France, Denmark, and Prussia they have been raised and held by the natural means before alluded to, covered and consolidated by suitable grasses, at an expense ranging from 30 to 70 cents per linear foot.

The cost of reclamation of the San Francisco downs with lupine will be less than $20 per acre. The subsequent sowing and protection of tree-seeds will amount to $25 per acre. . The cultivation of the principal grasses will cost from seed $15 per acre; by transplanting, $35 per acre.

There is still within the Golden Gate Park 500 acres of sand dunes upon which the lupine should be sown—500 acres, at $20	$10,000
Upon 300 of this 500 acres tree-seeds should afterwards be sown—300 acres, at $25	7,500
Upon 100 of this 500 acres grass-seeds should afterward be sown—100 acres, at $15	1,500
There are in addition to the above-mentioned 500 acres, 150 acres of sand dunes in Golden Gate Park upon which grass-plants should be set out—150 acres, at $35	5,250
Upon 50 of these 150 acres tree-seeds should afterwards be sown, but not plowed in or covered with brush, as in the lupine plantation—50 acres, at $10	500
Upon 50 of these 150 acres young trees and cuttings should be planted, which will cost $50 per acre	2,500
Besides which there are about 50 acres in the valleys of the downs within the park which should be resown with other kinds of grass-seeds (after the plants for reclamation have been raised in them and taken out) and planted with cuttings and young plants of suitable trees, which will probably cost $70 per acre—50 acres, at $70	3,500
	$30,750

Total cost of reclaiming so much of the sand-drift as is within the Golden Gate Park (700 acres) and starting young trees, shrubs, and grasses upon it will be then $30,750, or $43.93 per acre.

The above prices are established on estimates made with the knowledge of the cost of the requisite material at the present date, of the actual cost of most of the work (at current prices), and of the nature of all the labor to be performed, and it is quite certain that they are sufficiently high to cover all reasonable contingencies.

CAUSE OF THE APPARENT FERTILITY OF SAND DOWNS.

When the fact of the large number and length of roots which all plants adapted to sand-down reclamation throw out in such soil is considered, the rapidity and strength of their development no longer remain unaccounted for. The explanation is found in the great extent of matter from which they are thus enabled to draw their sustenance and in the capacity for holding water and warmth of the sands themselves. Thus although a given volume of dune-sand may not contain more than one-fifth of the chemical elements necessary for the growth of a plant, which an equal extent of firm forest-land does, the roots of plants propagated upon the loose soil will probably extend through ten times the bulk of material which can be penetrated by those upon the comparatively fertile, but more compact formation. Regarding the actual relative fertility of soils, their capacity for holding water, and retaining heat, a simple calculation is only necessary to demonstrate the superior qualifications of deep dune-sand formations over some soils generally thought to be more productive, for sustaining a high degree of vegetable growth, provided such plants be selected for cultivation as are suitable in each case. A most striking instance of this is presented in the growth of the pine used in the reclamation of the French sand downs; the average growth of this tree is 25 feet in the first ten years from seed on the downs, and but 17 feet during a similar period on the firm hill-land. On the sands it reaches an elevation of 90 feet; on firmer soil it has rarely been known to exceed 60 feet.

Another remarkable instance of this great growth is that of a sand willow in the San Francisco downs, whose roots were traced over 120 feet from the parent plant, one of which roots, measuring 94 feet in length, is now in this office,

In concluding this subject, I respectfully reiterate the terms in which it was spoken of, in the last biennial report, under date of December 30, 1871, which I had the honor of submitting:

"It will be necessary to devise some means also for stopping the encroachment of the sand from the sea-beach. In order to successfully accomplish these ends, the entire area of sand drift must be taken in hand at the same time, thus necessitating the co-operation of the owners of adjoining property with the management of the park."

PLANTS ADAPTED TO SAND-DOWN RECLAMATION.

The subjoined list of plants, with the remarks connected therewith, is simply a compilation of memoranda which might be of use to those who may hereafter prosecute the works of reclamation. It is by no means exhaustive of the subject, though longer than it was intended to be. The plants spoken of are those of whose efficiency in the departments of the work for which they are recommended there is ample precedent, which is the case with those spoken of, as having been used in Europe, or concerning whose adaptability to the purpose there is high scientific authority which may be said of those spoken of as having been recommended for plantation on the sands of Australia.

In the plantation of sand-downs, the primary object to be attained is the holding of the surface and prevention of drift for the first three months, during which time the real sand-plants develop and become firmly rooted. This object has been effected in Europe by means of coverings of brush-wood, protective palisades, and fences.

Common barley, sprouting from seed sown broadcast, answered the same purpose in the experiments made at Golden Gate Park, and it is probable that buckwheat and chicory plants, adapted to cultivation in light sandy soil and sprouting rapidly from seed, will answer this temporary purpose equally well.

There are few, if any plants hitherto used upon sand reclamation which develop rapidly enough on dry dunes to take the place of the annuals above mentioned, when they begin to fade, and it is this purpose which the lupine answers so well, effectually stopping all drift and producing by its rapid growth the material for future works of protection which the seedling trees require.

TREES.

Maritime Pine (*Pinus Maritimas*), sometimes called the French Pine or Sea Side Pine.—The tree so extensively and successfully used in reclaiming sand downs in France. It is grown from seed on the sands; the young plants develop very slowly for the first two years; they then grow faster each succeeding season, and attain upon the French coast downs a height of 12 feet when six years old, 25 feet when ten years old, and a maximum elevation of 90 feet.

The seedling plant must be protected from drifting sand and heat of the sun, and the sand about them kept moist by being shaded with brush wood or growth of some vegetation.

This pine is adapted to cultivation upon the greater part of the San Francisco downs, including the highest and most arid portions. The seed should be sown in wide rows or belts through the lupine plantation, when these latter plants are one year old, and the portion thus sown in pine should be covered by the lupine bushes which shall have been removed from them.

Cluster pine (*Pinus pinaster*).—A native of the sandy shores of the Mediterrancan, where it is a natural reclaimer of drifting downs. This tree is frequently confounded with the Maritime Pine, and good authorities differ upon the subject. It is cultivated upon the downs of France and other portions of southern Europe, where its treatment, rate of development, and growth are very much the same as those of the Maritime Pine, but it does not attain so great a height.

It is one of the trees best adapted for the work of reclaiming the San Francisco downs. It should be cultivated like the Maritime Pine, as indeed should all trees which are raised from the seed on the sands themselves.

Scotch Fir (*Pinus sylvestris*).—Cultivated successfully upon the Prussian and other northern sand-downs from seed and also by setting out young trees. Better adapted to cold climate than either *Pinus maritima* or *Pinus pinaster*.

Although a native of northern latitudes and grown generally in moist climates, it has been successfully introduced upon the driest sandy wastes of Australia and is highly recommended for planting on sand downs in this country.

It will probably succeed on the more exposed and moist localities of the San Francisco downs.

Larch (*Pinus larix*).—Recently used most successfully upon European downs, particularly in reclaiming those of France and Prussia.

It may be a most valuable tree for the foresting of the San Francisco downs.

Tamarisk (*Tamarix*).—A family of beautiful small trees and shrubs, of which the

French species, *Tamarix gallica*, and the German, *Tamarix germanica*, have been extensively used in sand-down plantation and on sea-side exposures in the southern part of Europe and England. These plants stand the sea winds and salt-water air better than any other shrub or tree. They are readily propagated from cuttings upon the moist places in the downs themselves. The Arabian Tamarisk, *T. orientalis*, is found growing in the sands of the desert where no other vegetation exists, and the African variety, which is but a shrub 6 or 7 feet high, is a native of the sandy shores of the Mediterranean. All of these plants, particularly the two first mentioned, are adapted to cultivation upon the San Francisco downs.

Japan Varnish Tree (*Ailantus glandulose*).—A tree of most rapid growth in sand. But recently come into notice for purposes of reclamation in Europe and proven itself one of the best for the purpose.

May not thrive in the more exposed places, but will no doubt succeed well in the valleys of the San Francisco downs.

Common Alder (*Alnus glandulosa*); *Northern Alder* (*Alnus incana*).—Cultivated in valleys of the downs in Prussia. May be adapted to moist valleys of San Francisco downs.

Sea-side willow (*Salix argentea*).—Much used in the construction of shore-dunes in France, and will answer a similar purpose here.

Sand willow (*Salix arenaria*).—One of the best trees for sand reclamation in localities where much moisture exists. It does not suffer much from being nearly covered with drifting sand, but throws out new roots from every joint covered, and seemingly thrives the better from being in the drift.

This tree has been used to a great extent upon sand-downs throughout Europe.

Coast sheoak (*Casuarinaq uadrivalvis*).—Recommended as one of the most important trees for arresting the ingress of coast sand in Australia, and should be tried here.

Desert sheoak (*C. glauca*).—Also recommended for sand plantations in Australia and worthy of trial here.

"*Sandstay*" (*Leptos permum lævigatum*).—This shrub, or small tree, is the most effectual of all for arresting the progress of drift-sands in Australia, and consequently should receive special attention here. It may be raised from seeds upon the sand-down itself, like the pine.

"*Sword sedge*" (*Lepidosperma gladiatum*).—One of the most important plants for binding sea-sand in Australia. It should be used here.

Common broom (*Spartium scoparium*).—A tall, handsome bush, bearing a profusion of yellow flowers, which grow readily from seed on sand-downs. One of the first plants used in France in the works of reclamation, for which purpose it occupies a position in the front rank of the shrubs which have been tried. The broom should take the the lupine on the San Francisco downs, when the latter begins to die, at the place of end of the third year. This plant attains the height of 5 feet on the French downs in four years.

Spanish broom (*Spartium monosperum*).—A beautiful large shrub, with sweet-scented snow-white flowers. Used successfully in southern Europe to reclaim drift-sands. Will answer the same purpose here as the common broom, which it much resembles.

Common furze (*Ulex europæus*).—Called by the French "prickly broom." A low-growing, coarse shrub. One of the first and most successful sand reclaimers used in France. Will probably succeed well with the lupine here, but is not particularly desirable. Attains a height of 3 feet on French downs in four years.

There are other trees and shrubs which have been cultivated with a fair degree of success, or recommended by different authorities for plantation on shifting coast sands.

Among these the common elder may be mentioned as enduring the heavy winds remarkably well and growing luxuriantly in pure sand if it be sufficiently moist. The beech, plum, *Prunus maritima;* common heath, *Erica communis;* New Zealand flax, *Phœmium tenax;* several members of the Genista (allied to the brooms) family, two California pines, *Pinus insignis* (Monterey pine), a native of the sea-side south of San Francisco, and *Pinus contorta*, a low, coarse-growing plant found upon the shores of the northern part of the State, should receive attention as secondary trees, likely to thrive in the moist places of these downs. The same may be said of the Monterey cypress, several of the eucalyptus, and acacias; but, as these trees have never proven themselves to be adapted to this purpose, and we can only conjecture from their habit that they will do well, they should not receive much attention during the primary operations.

GRASSES.

"*Mat-grass*" (*Psamma arenaria*); "*Sand reed*" (*Arundo arenaria*).—This grass stands at the head of the sand binders, having proven itself to be far superior to all others for the coast plantations on all the great works of reclamation.

Under the names of "beach-grass," "sea-grass," "mat-reed," "mat-weed," and "marum," or "murram," it has been used at many points on the coast of England to reclaim sandy tracts.

It is planted on the shore-dunes of the Prussian sands of the Pomeranian coast, where it is known as the "Hugelrohr."

It is the principal agent in the works of reclamation upon the Danish sand-downs, and it is preferred in that country to plantations of trees. The Danes call it "klit-tag" (sand-sedge).

Nearly all the dikes of Holland are covered with this grass, and much of the drifting sand-waste of that country has been reclaimed by it. It is there known as "Helm," or "Dachgrass."

The French call it "Roseau de Sables," and now also accord it the precedence for the beach plantations, though the next-named grass, *Elymus arenarius*, was at first used by them as the best.

It is a strong and rapid-growing reedy grass, which throws out its roots horizontally and rears its leading stalks diagonally upward. It sprouts new roots and new leaf-stalks from each bud covered by the drift, and thus spreading through the sand, finally binds it by a perfect net-work of vegetation. So far from being injured, it is seemingly refreshed by a shower of drift-sand, and dies out when complete reclamation has been attained and other plants take its place.

It should be raised from seed in the moist valleys and near the beach of the San Francisco downs, whence the roots, plants, and cuttings may be transplanted to the beach for the purpose of erecting and maintaining the shore-dune, as elsewhere described, and to any other portion of the drift when desirable. Its growth from seed on the dry dunes is too slow during the first year to allow of its being raised in this way where it will be subjected to much drift, and therefore it could not be depended on here to take the place of the lupine, though it will no doubt prove to be the best plant for use near the beach.

Sea lyme grass (*Elymus arenarius*).—Strong, rough, glaucuos grass, standing next in order of efficiency for sand and reclamation purposes to the mat-grass.

It has been employed successfully in the maintenance of shore-dunes in France, where it was brought into notice under the name of "Courbet" some years after the first reclamation was effected with the pine, and this tree was proven not to thrive when planted immediately upon or near the beach.

The Hollanders were probably the first to make use of this valuable grass in the construction of sea-beach works. The fascenes of straw with which their protective dikes are often faced, and in a measure built up, are bundles of the stalks and leaves of this grass, which attain a length of 4 or 5 feet, from which characteristics the Dutch name for it signifies "long straw." It has been used to a great extent on the Holland downs and sea-dikes, and although it is not as effectual a reclaimer as the "mat-grass," it is sometimes preferred to it for the reason that its straw is useful for many domestic purposes.

The Lyme grass is not plentiful on the Denmark sands, where it is found only in limited localities, close to the salt water, and is hence called "sea-weed." It has been used in reclamation on the Baltic downs of Prussia, where it is called the "Sand-hair grass," and is esteemed above the mat-reed for inland plantations. It has been used very successfully in England, where it is mixed with the "bent grass," next described, and is sometimes called the "reedy bent," although of a different family. This plant thrives best when receiving fresh supplies of drift-sand over it occasionally, but throwing out its shoots more nearly horizontally than the "mat-grass," does not grow through the sand and cover it as quickly or effectually as the latter.

It would thrive better on the higher portions of the San Francisco dunes than any other grass, where it may be grown from the seed, but the safer plan will be to propagate and use it in the same manner as prescribed for the mat-grass.

Bent grass (*Agrostis*).—There are two varieties of this grass adapted to cultivation on very loose sandy soils, the "Common bent grass" (*Agrostis vulgaris*) and the "Fiorine bent grass" (*Agrostis stolonfera*), each possessing the characteristic of spreading over a great extent of surface by means of their long runners, which root afresh at the joints, and interweaving with each other, form a carpet over the ground, which makes them useful upon light soils. These grasses do not stand being covered by drift like the mat-grass and lyme grass, and hence, not having their roots deeply set, are not adapted to the primary purposes of reclamation. They have been used successfully upon such works in England and Ireland, where showers of rain fall at short intervals throughout the year, but have not received any attention as reclaimers on the Continent of Europe. They will be amongst the best grasses for cultivation in the valleys of San Francisco dunes after the reclamation has been effected.

"*Couch grass*" (*Triticum*).—There are two varieties of this grass adapted to sandy soils, the "Common couch" (*Triticum repins*) and the "Sand couch grass," (*Triticum junceum*), of which the latter has been used to some extent on works of reclamation in England. Their habit is much like that of the bent grass, and their long white stalks are known to extend under the surface of loose soils for many feet. These grasses are well adapted for plantation upon the San Francisco downs after the reclamation has been effected.

There are several other varieties of grass whose habit of growth and adaptability to cultivation in poor soils under a dry climate make them desirable for plantation on the San Francisco downs after the reclamation has been effected to some extent. Among these may be mentioned the "Dogtooth grass" (*Cynodon dactylon*), the "Creeping fescue-grass" (*Festuca rubra*), and the "Sinew grass" (*Carex arenaria*), as well as a variety recently introduced into California under the name of Sandwich Island grass.

THE GREAT HIGHWAY.

The Great Highway is a strip of land from 200 to 400 feet in width, above ordinary high-water mark, extending from the Cliff House Bluff southerly along the ocean beach for a distance of about $2\frac{7}{8}$ miles.

As before stated, the arresting of the sands at the beach and ultimate entire stoppage of the supply brought on shore by the waves is the most important and should be the first step in the work of reclamation. So that the management of this highway constitutes the key to all success upon the downs. Each billow that breaks upon this gently sloping shore forces a quantity of sand before it by the blow, stirs up and carries forward, suspended in its foaming fragments, still more of the same material, all of which as wave after wave dashes on, is finally deposited just at the limit of the highest running breaker of the flood.

Along this line a considerable increase in the slope of the beach may be seen, just above which a slight ridge, less than a foot in height and varying in width from 10 to 20 feet, is readily observed and recognized as the installment of sands brought up by each ordinary high tide, while the amounts thus left after the storm floods are still more extensive. The sands of this ridge are being continually dried and carried inland by the winds, while their place is as constantly filled by the fresh material brought forward by the waves.

Observations made and experiments conducted upon the sands at Golden Gate Park during the past year, indicate that about 800 cubic feet of sand to each linear foot of beach is thus contributed to the San Francisco downs every year. This amount exceeds that brought upon any of the European shores by about 200 per cent., and being ascertained by only one season's experiment, may prove to be exceptional, though probably not far from the correct figure in the present state of the beach.

The transportation of finely-divided material, such as sand by running water, and the degree of inclination in a bottom line up which it may be forced and deposited by an advancing wave, are problems solved by known rules, based upon experiment, observation, and practical experience in engineering work. The familiar circumstance that sands are thrown up by the waves in great quantities upon wide, flat beaches, to a limited extent upon steeper shores, and scarcely at all on a beach at the foot of a bluff to which high tide reaches, is sufficient demonstration of this fact for present purposes.

Thus, a flat sea-beach being given by artificial means, a slope from a point several feet below low-water line to and above high-water level, of such inclination that the waves can not force sand upon it, and upon which the material deposited by the water will not lodge, the end will have been accomplished—the advance of the sand stopped—for the water of each wave will carry back in the undertow that which it brought up in suspension. This rule applies to such beaches as the one reserved here for a great highway, but not to coasts like some to be found in Europe, where the very fine sands move and form banks under water, which, continually shifting, sometimes move upon the shore-line in a manner similar to the advance of the great ridges in the upland downs.

The rearing of downs and their progress before the winds are matters to which attention has been given where works of reclamation have been contemplated, so that the laws of their formation are well established, and we are enabled to predict the size and shape of, and the position in which a hillock will be raised by the interposition of various obstructions to the advance of the sands. Should a series of brush hedges or wicker-work fences be erected along a shore-line, at such distances from the water as to render the outlying row safe from the run of the highest waves, the sands brought upon the beach would be piled up in a hillock about them, and a continual raising of the fences would result in a corresponding elevation of the down, as more sand was brought up, and a proportionate increase of its seaward slope, until such an angle of inclination was reached that, as before remarked, no more sand would be deposited by the waves. If a belt of plants of the two first-mentioned grasses in the list herewith given—the mat grass and the lyme grass—be planted at a suitable distance from the water, their leaves and stalks would grow readily through and retain the drift which will be blown over them; new roots will be thrown out, and interweave throughout the down so formed, and the sand will then be bound into a firm ridge, whose slope will gradually advance seaward, and the stopping of all supply of material to the inland downs will have then been accomplished.

These two methods of forming protection downs have been in use for many years in

Europe, having supplanted the more costly artificial works on sandy shores, except at the most exposed places, and where the land to be protected is much below the level of the sea. It is the latter plan, assisted somewhat by the former, by which it is proper to form a bulkhead upon the outer portion of the Great Highway, as shown in section at A in the adjoined diagram.

With the quantity of sand above given—as brought upon the beach each season—at the end of four years there would be a ridge, equivalent in cross-sectional area to that of a rectangle with 160 feet base and 20 feet perpendicular, reared at an expense of only the cost of brush hedges, grass plantation, and some care thereof. Upon the top of this embankment a road, overlooking the surf and flanked by rows of suitable bushes, might be built; its inner slope might in time be covered by a dense growth of trees, in the shelter of which another spacious drive, at a level 15 feet below that on the bulkhead, could be constructed, with a sidewalk along the line of property on the east, and rows of trees intervening. The seaward slope of the dike, being of gentle inclination and covered with mat grass, would continue to advance until it arrived at a line where storm waves would occasionally do it much damage; at this point it should be assisted or protected by artificial means.

Thus at the end of ten or twelve years the amount of sand brought up by the waves being decreased each year since the commencement of the work by reason of the continued increase in the slope of the beach, there would be an embankment erected by the forces of nature and protected and improved only by artificial means.

During the interim the sheltered drive may be built and used in lieu of the beach the first year of the work, and the other structures gradually added as required.

Respectfully submitted.

WM. HAMMOND HALL,
Engineer.

BOARD OF PARK COMMISSIONERS,
San Francisco, Cal.

D.—LETTER ON THE SUBJECT FROM THE CHAIRMAN OF THE COMMISSIONERS OF GOLDEN GATE PARK.

SAN FRANCISCO, CAL., *February* 14, 1890.

DEAR SIR: Your communication of the date February 6, addressed to Mayor Pond, having been referred to the park commissioners, I will be pleased to state that we have no published information in the way of reports in reference to the reclamation of sand dunes.

Following is the manner in which all the reclamation of the sand dunes in the vicinity of the park has been done.

All strong-growing grasses with creeping or pointed roots are good for holding the sand. The best variety is the one planted here, viz, the Holland grass, *Arundo arenaria.*

The best way to plant it is to plow the roots in, say in every third furrow drop in the roots about 2 feet apart, covering them with the plow. Then plow another three furrows, and drop in another row of roots, and so on. When the sand drifts are too steep for the plow, or where there are other plants growing in patches, the way they do is to dig pits say about 12 inches deep and the width of a spade. In the bottom of the pits drop a few of the roots, refill the hole, and press the sand down firmly with the foot. Dig the pits about 3 feet apart. After the grass is planted sow the ground thickly with lupin seeds, covering the seeds with a hand rake. The following year plant the whole about 4 feet apart with some hardy variety of pine.

Very respectfully,

R. P. HAMMOND, JR.,
Chairman.

Capt. THOMAS W. SYMONS,
Corps of Engineers, U. S. A.

T T 3.

IMPROVEMENT OF UMPQUA RIVER, OREGON.

DESCRIPTION OF ORIGINAL CONDITION.

Just below Scottsburgh, the head of navigation on the Umpqua River, are five sandstone bars or ledges, 12 feet to 15 feet wide and submerged from 1 foot to 2 feet at low tide on a low-river stage. They

are separated by pools about 150 feet wide and from 5 to 10 feet deep at low water.

PLAN OF IMPROVEMENT.

The honorable Secretary of War having authorized the expenditure of the balance remaining of the appropriation of March 3, 1871, viz, $4,685.89, in improving the river below Scottsburgh, a project was submitted and approved in 1885 for making, at an estimated cost of $4,056, a channel 50 feet wide and 3 feet deep at low water through the rock ledges above described by drilling and blasting the rock and removing the broken pieces to deeper water in the pools.

APPROPRIATIONS.

Act of March 3, 1871	$22,500
Act of August 11, 1888	2,000
Total	24,500

AMOUNT EXPENDED TO JUNE 30, 1889.

The amount expended on the project to June 30, 1889, was $4,675.14.

RESULT OBTAINED TO JUNE 30, 1889.

The result obtained was an increase in the depths of water over some of the reefs, through a channel 50 feet wide from 1 foot at low water, which formerly existed, to 2 feet at low water.

EXPENDED DURING FISCAL YEAR ENDING JUNE 30, 1890.

The amount expended during fiscal year ending June 30, 1890, was $1,983.28.

RESULTS OBTAINED TO JUNE 30, 1890.

The result obtained has been to increase the extent of the low-water navigable channel above mentioned to a depth of 2 feet.

REPORT OF OPERATIONS.

The work done on the Umpqua Rvier consisted in drilling, blasting, and removing rock reefs near and below Scottsburgh. About 700 tons of rock were so removed.

In compliance with the terms of the river and harbor act of August 11, 1888, a survey was made of the Umpqua River from Scottsburgh to its mouth, and report submitted January 16, 1890. This is contained in House Ex. Doc. No. 199, Fifty-first Congress, first session. In accordance with the views therein expressed, I do not recommend any further appropriation at the present time for this river.

Money statement.

July 1, 1889, amount available	$2,010.75
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,983.28
July 1 1890, balance available	27.47
Amount appropriated by act of September 19, 1890	9,000.00
Amount available for fiscal year ending June 30, 1891	9,027.47

COMMERCIAL STATISTICS.

Umpqua River is in the collection district of Southern Oregon. Empire City, on Coos Bay, is the nearest port of entry. The nearest light-house is at Cape Arago; entrance to Coos Bay, distant 22 miles.

The river below Scottsburgh is a part of a tri-weekly mail route from Drain, on the Oregon and California Railroad, to the lower river district and to the lower Siuslaw and to the Coos Bay region. The distance by wagon road from Drain to Scottsburgh is 36 miles, while the distance from the railroad to navigable waters on the mail routes next north and south of the Umpqua route is about 60 miles.

For six years, at least, the mail-boat on the Umpqua has been a small tug, which draws 4 feet, carries passengers and express, and tows a scow for carrying freight. The tug is more economical than a stern-wheel boat would be, and is better adapted for service near the mouth of the river, where there are two mail landings. There is another steam craft working on the lower river and generally used in towing logs. A bar-tug is stationed at Gardiner, near the river-mouth, which has, however, no special cause for going above.

There is a tannery at Scottsburgh whose product is shipped to San Francisco. Farm products are also taken down the river for shipment to San Francisco, and to supply the logging camps and Gardiner, where there is a large saw-mill, which maintains a lumber trade by vessel to San Francisco.

The following returns, furnished by Mr. William R. McKenzie, Gardiner, Oregon, are for the year ending June 30, 1890:

	Number.
Vessels arrived	39
Vessels cleared	38

The cargo capacity of these vessels, lumber laden, is from 625 to 1,750 tons, their draught when loaded being from 12 to 15 feet.

River traffic.

Steamer *Juno* (propeller)	tonnage..	2,228
Miles run during year	number..	8,730
Passengers carried during year	do....	2,174
Amount of freight carried during year	tons..	809
Steamer *Restless* (stern-wheel)	tonnage..	101.02
Miles run during year	number..	5,200
Passengers carried during year	do....	1,354
Amount of freight carried during year	tons..	1,083

Imports and exports.

	Tons.
Imports—	
Machinery and general merchandise	1,500.0
Exports—	
Lumber	27,342.0
Laths	603.8
Salmon (cases)	406.0
Grain	526.0
Wool	20.0
Leather	7.0
Hides and furs	26.0
Butter and cheese	2.0
Total	28,926.8

The tug-boat *Fearless* went to pieces on the bar the evening of November 19, 1889, while endeavoring to cross in; all on board were lost, six (crew) and one passenger.

T T 4.

IMPROVEMENT OF THE ENTRANCE TO YAQUINA BAY, OREGON.

DESCRIPTION OF ORIGINAL CONDITION.

The usual prevailing depths over the bar, at low water, before improvement, were from 7 feet to 8 feet. Three distinct channels existed,

known as the north, middle, and south channels. The south channel was the one mostly used, but was rendered dangerous by the presence of rocks. The middle channel, though free from rocks, was usually the shoalest of the three, and so was little used. The north channel, besides being long and tortuous, was so studded with rocks as to be considered unnavigable. Owing to the shifting nature of the bar, these channels were constantly changing, both in position and depth.

The mean rise of tide was 7.1 feet.

PLAN OF IMPROVEMENT.

The project adopted in 1881 was to run out a dike or jetty on the south side of the entrance, so as to cause the south channel to shoal up and the flow to be deflected northward, with a view to opening and maintaining the central channel with a least depth of 17 feet at high water.

As originally projected, the dike was to start from near low-water line and run out into the sea a distance of 2,500 feet, and was to rise to 2 feet above mean low water. The beach on the line of the jetty from high-water level was to be protected by sinking gabions in the beach, with sand heaped over them and by covering the surface with a layer of mattresses and stone.

The stone for the jetty was to be deposited in place from barges, and cribs were to be used if practicable. It was found, however, that cribs could not be used on account of the strong currents and high seas, and that the ocean swell even in quiet weather was too great to permit the use of stone-barges. Accordingly the jetty had to be built from the shore end by carrying the stone out over a tramway, and was begun at high-tide line instead of at low-tide line, thus making the total projected length of the jetty, in 1881, 3,700 feet.

In 1884 the jetty was extended shoreward a distance of 316 feet, to close a gap that had been washed out by the sea, making the total projected length of the jetty at that time about 4,000 feet.

The present project, adopted in 1888, is to raise the south jetty to full high water without extending it seaward, thus making its total length 3,748 feet; and to construct a mid-tide jetty on the north side of the entrance, about 2,300 feet in length, extending from the north head along and behind the reef, putting out from the head to a point opposite the end of the south jetty, and distant from it about 1,000 feet.

APPROPRIATIONS.

Act June 14, 1880	$40,000
Act March 3, 1881	10,000
Act August 2, 1882	60,000
Act July 5, 1884	50,000
Act August 5, 1886	75,000
Act August 11, 1888	150,000
Total	385,000

AMOUNT EXPENDED TO JUNE 30, 1889.

Amount expended to June 30, 1889, was $332,631.25.

RESULTS OBTAINED TO JUNE 30, 1889.

At that date the south jetty had been completed to its entire length as projected by the Board of Engineers, and the north jetty to a length of 300 feet, and work was being actively carried on.

The result on the harbor entrance was to keep the bar channel more in one place and to increase the depth over the bar. The south channel had been permanently shut off, and the tendency of the waters to go to the north restricted.

AMOUNT EXPENDED DURING YEAR ENDING JUNE 30, 1890.

Amount expended during the year ending June 30, 1890, was $50,867.12.

RESULTS OBTAINED TO JUNE 30, 1890.

The south jetty was built up to full high water without being extended, about 18,040 tons of stone being used.

The north jetty was extended 820 feet in length, 12,980 tons of stone being used on this extension.

The result of all this work has been to cause the channel to run in a direct line out to sea and to maintain an ordinary depth of 11 to 12 feet at low water.

As at the Coquille River entrance, sand has formed not only behind the south jetty for its entire length, but it has tailed out beyond the jetty some 500 feet, forming a low training-wall of sand directly in line of the jetty. A heavy deposit of sand has also formed on the north side of the channel in about the contemplated position of the end of the north jetty; this rises above low water. At low water, from the hills on the north side of the bay, the channel is very well defined, running directly out to sea between the jetties and the natural sand extensions above referred to.

REPORT OF OPERATIONS FOR FISCAL YEAR ENDING JUNE 30, 1890.

During the year 820 feet of tramway was constructed for the north jetty and about 12,980 tons of stone were placed on this jetty. About 18,040 tons of stone were placed on the south jetty; 20 new dump-cars were constructed. Active operations were suspended on November 15, 1889, since which time surveys have been made of the quarries of the bay shore-lines and jetties. Twenty cross-sections were taken of the south jetty and platted. A four-room dwelling for assistant engineer's quarters was built. During the winter season, 23,400 feet (linear) of piles were purchased for future use.

RECOMMENDATIONS AND REMARKS.

The recommended amount of $75,000 for the completion of the present project made by my predecessor was believed by people interested in the improvement of the bay to be too small, and in consequence a re-estimate was asked for and, under instructions from the Engineer Department, was made by me, and it with my report was printed in Senate Ex. Doc. No. 47, Fifty-first Congress.

A careful study of the action of the sea on the jetties during the past winter convinces me that the cross-section of the jetties estimated for therein is excessive and that the results desired can be equally obtained and maintained by jetties of smaller cross-section. The sand has formed in behind the south jetty, so that it is practically a revetment wall rather than a jetty. If the same thing occurs at the north jetty, as recent events seem to indicate, the total cost to "surely complete and give the requisite strength and stability to the work, accord-

ing to the present project," will be very materially reduced from the amount previously estimated at $370,560.30. (Senate Ex. Doc. No. 47, Fifty-first Congress, first session.) If the amount (in Senate bill) of $185,000 is secured for the work this year, I estimate that with the plant on hand $125,000 can be profitably expended the next year. This will probably be enough to fully complete the project, depending on the difficulties met with in building the north jetty and the readiness with which the sand formation continues.

FUTURE OPERATIONS.

It is expected with the money available from the next appropriation, if any such there be, to complete as far as possible the north jetty before undertaking any work on the south jetty.

Money statement.

July 1, 1889, amount available		$43,368.75
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$41,867.12	
July 1, 1890, outstanding liabilities	1,154.00	
		43,021.12
July 1, 1890, balance available		347.63
Amount appropriated by act of September 19, 1890		165,000.00
Amount available for fiscal year ending June 30, 1891		165,347.63
Amount (estimated) required for completion of existing project		145,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		125,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. J. S. POLHEMUS, ASSISTANT ENGINEER.

NEWPORT, OREGON, *June* 18, 1890.

SIR: I have the honor to submit the following report of operations on the harbor improvement work at Yaquina Bay, for the year ending June 30, 1890.

At the commencement of the fiscal year, work was in active progress in the expenditure of the river and harbor appropriation of $150,000 of August 11, 1888, in accordance with the plans of Capt. W. Young, of September 1, 1888, approved by the report of the Board of U. S. Engineers, dated November 13, 1888.

In brief, these plans contemplated the construction of a mid-tide north jetty of heavy stone riprap, extending about 2,300 feet from the north head, leaving the entrance width 1,000 feet. Also the raising the south jetty by rock, riprap, to full high tide, without further extension.

As stated, the work was in active operation, July 1, 1889, and the plant in full use.

Wharves, approaches, shore trestles, derricks, scows, etc., were built, and over $100,000 of the appropriation was expended leaving an available balance of $43,368,75.

The south jetty was receiving a final covering of heavy stone, and the north jetty had been extended about 300 feet, and the tramway and enrockment were being pushed seaward at the rate of about 500 feet per month.

The stone supply was obtained by hired labor from the Mill Creek quarry, on the bank of the Yaquina River, about 14 miles above the jetties.

QUARRY OPERATIONS.

Up to July 1, 1889, about 33,000 net tons of stone had been loaded on the scows since the previous September.

On November 15, the last scow had been loaded and quarry work ceased.

Since July last, 139 scows were loaded with about 30,580 net tons of quarried stone.

The total for the whole appropriation of August 11, 1888, was 289 scow loads, equal to about 63,580 net tons.

To ascertain the amount of stone obtained, the displacement of the scows was measured for each one-tenth of a foot of draught, and the draught of the scows light and loaded, observed by means of four guages attached to the sides.

The new scows carried about 275 tons each, and the old ones, when full loaded, from 200 to 240 tons.

As some small stone of poor quality was used, I have taken 220 tons as the average load brought down per scow, it being somewhat less than the actual weight carried.

All of the product of the quarry was taken that was fit to use for any purpose, and consequently about one-tenth of the output was of inferior quality, and some small size, but in our case it answered a good purpose in being dumped around the tramway piles for the cove of the jetty.

The stone at the best is a poor quality of sandstone, weighing 140 pounds to the cubic foot; rather soft and liable to disintegrate when dry and exposed to the air.

All sizes were used, from 100 pounds to 4 tons, the average weight of pieces being about 1 ton.

The workable face of the quarry is about 600 feet long, and the average depth of the good ledge, from where it can be conveniently worked at the river bank to the stratum of loose rock at the top, is about 40 feet.

There is an average depth of soft rock and earth on top of this of 40 or 50 feet more, which increases as the face is worked into the hill.

The stone is blasted out with block powder, and the larger pieces broken again with plug and feather.

In quarrying the above amount of stone three hundred kegs of powder were consumed and 1,300 pounds of giant powder (No. 2) for springing holes and removing the soft rock above.

The main quarry is rented from Mr. C. H. Williams at $325 per year. The Government obtained by purchase 2.7 acres adjoining.

The stone is loaded on the scows by two floating derricks.

The debris for the most part was loaded on the scows and dumped thence against the bank of the river above.

It cost the Government for the 63,580 net tons loaded on the scows at the quarry, not taking into account the cost of plant, but allowing $1,000 for depreciation thereof, and including rent, purchase of land, buildings, etc., $29,619.65, equal to 46½ cents per net ton of all stone used.

In the future it will cost more, as the stripping to be handled increases in proportion to the good stone as we work into the quarry.

The Government condemned and purchased the "Canon Quarry," of some 19 acres, on the river about one-half mile above, where an additional supply can be obtained.

The conditions as to quality of stone, stripping necessary, loading facilities, etc., are similar to those existing at the Mill Creek quarry.

MATERIALS OF CONSTRUCTION.

The lumber used for wharves, jetty tramway, buildings, etc., was yellow fir, purchased in open market from the local saw-mills at from $10.50 to $12 per thousand for undressed, loaded on scows at the mills.

The piles were obtained from the country adjacent to the headwaters of Depot Slough, and cost last year 6 cents per lineal foot, delivered in rafts near Toledo.

After the close of the work, last autumn, a contract was made with Copeland & Wade, after due advertisement, inviting proposals to furnish 480 piles from 44 to 52 feet long, about 2,300 linear feet, and enough to complete the north jetty as projected; the piles to be put in tide water during the winter, with the bark on, as it affords some protection against the terredo.

These piles are now in tide water of Depot Slough. The price to be paid is 8 cents per lineal foot, rafted in navigable tide water.

Wood for fuel was purchased in open market, and cost, delivered on the river bank or on scows, $3.50 to $3.75 per cord for 2-foot fir wood.

Coal, powder, rope, iron, spikes, nails, oakum, paints, oils, etc., were purchased in San Francisco or Portland, and shipped in.

The country surrounding Yaquina Bay has been the scene of a great timber fire, forty or fifty years ago, which consumed the greater part of the forest for miles in extent; and now the available timber for piles, saw-logs, or even fuel, is becoming more expensive and difficult to get every year.

TOWING.

Two steam-boats were chartered to do the Government towing: the *Walluski*, a flat bottom screw-boat drawing 4½ feet with 10 by 12 high-pressure engine, with crew, completely found, for $600 per month; also the steam-boat *Favorite*, a small propeller, drawing about 5 feet, with crew, fuel, etc., for $550 per month.

These boats could bring down two loaded scows from the quarry to Newport with the tide in about four hours.

One boat was generally used to tow the scows to and from the quarry, and the other to take the scows between the mooring and South Beach Wharf at high tide.

The amount paid out for towing for all purposes from September 1, 1888, to November 30, 1889, was about $10,550.

The towing of the stone from quarry to the jetties cost a little less than 15 cents per ton. It was rendered thus expensive on account of the shoaling in the channel leading to South Beach, whereby loaded scows could only be taken in at the top of high tide.

PLANT.

The principal items of plant, not considering the jetty tramway, approaches, and wharves as such, are: The steamer *General H. G. Wright*, formerly used for towing, but not in the service last year.

Ten scows for carrying stone, six old ones built in 1880–'81, and capable of carrying about 200 tons each, and four new ones built in 1888–'89, with a carrying capacity of 275 tons on 5 feet draught; they are 90 feet long, 27 feet wide, and 6 feet depth of hold. Two of these scows were provided with strong derricks, and employed in loading the stone at the quarry.

Two 15-ton derricks, one on the wharf at South Beach, and one at Newport, each supplied with a Lidgerwood double cylinder 12 by 12, 50 horse-power hoisting-engine. These engines cost F. O. B. cars at Yaquina $1,900.

One revolving pile-driver, complete, for extending north jetty tramway.

One spare hoisting-engine at South Beach; making a total of six hoisting-engines.

Two 5-ton 6 by 10 cylinder locomotives, made by H. K. Porter & Co., the latest costing $2,500 in San Francisco.

Forty strong dump-cars, twenty of which were purchased in 1889 from the Taylor Iron Works of New Jersey, and cost, complete, at Yaquina, about $230 each.

Three steam-pumps.

A complete outfit of small tools and appliances for carrying on the work, including small boats, anchors, hand-pumps, push-cars, tackle-blocks, etc.

SOUTH JETTY.

The work done on the south jetty during the fiscal year consisted simply in riprapping it with heavy stone.

From July 1, 1889, to November 15, 1889, eighty-two scow loads of 18,040 net tons were placed on the main jetty, which, at the close, brought it up to full high-tide. During the last winter the stone has settled and compacted, until now the highest tides wash over it, but in the main it is in excellent condition and the jetty tramway has suffered no damage. The work on the south side was somewhat annoying, as during last fall the channel leading to the receiving wharf had shoaled so that scows could only be towed in at the top of high water, and that with difficulty and risk.

NORTH JETTY.

The north jetty tramway had been completed for 300 feet on July 1, 1889, and two scowloads of stone delivered on the jetty.

The plant was all in working order except the putting together of the 20 new dump-cars.

The sea end of the tramway was 2,110 feet from the receiving wharf.

From July 1 to October, 1889, when the work ceased, the tramway was extended seaward 880 feet, making a total of 1,180 feet of north jetty.

From July 1 to November 15, 1889, fifty-nine scow loads (12,980 tons) of stone were placed on the north jetty; in all on the north side to date, sixty-one scow loads, or 13,420 tons. The greater part of this went to the jetty proper, and raised it nearly to ordinary high tide, as this was found necessary to support and hold the tramway. About 1,000 tons of stone were placed as a revetment to the tramway approach to afford it protection against the high tides and drift of winter.

The north jetty tramway was built on four-pile bents 10 feet apart, driven into the bed rock from 3 to 8 feet by the revolving pile-driver.

The piles were capped with pieces of timber 10 by 12 by 22 feet, on which rested stringers 12 by 12 by 20 feet, carrying the rails.

The bents were afterwards sway-braced with 3 by 9 pieces.

The elevation of the track above the plane of mean lower low water is 22 feet.

Some difficulty was experienced in driving the piles, as the bed-rock is moderately hard and difficult of penetration. In places it was only covered with one or

two feet of sand; not a sufficient depth to hold up the piles unless driven into the rock.

A 2,000-pound hammer was used, and the average progress of extending the tramway was 500 feet per month. At the sea end of the tramway, when work closed, the top of bed-rock was 6 feet below the plane of mean lower low water.

The double-track tramway cost, complete, with rails, $4.84 per linear foot, not counting the cost of plant.

The stone placed on the jetty was hoisted from the scows by the wharf derrick to the cars, and run out by the locomotive in trains of 6 to 8 cars, carrying 5 tons each, and dumped from either track on both sides. The tracks are 14 feet apart from middle to middle.

It cost in labor, fuel, etc., last year, 17.8 cents per ton to discharge the scows and run out and dump the stone on the jetty. This figure can be reduced, however, by having a plentiful supply of good-sized stone.

MISCELLANEOUS.

All active operations on the jetties came to an end by the last of November on account of exhausting the appropriation.

The scows and the *General Wright* were moored alongside the piles at the Mill Creek quarry, and all the Government property stored away and put in the charge of two watchmen.

During the winter some violent storms occurred, and at one time the highest freshet known in the river for twenty years occurred. No damage was caused to the jetties or Government property, but many drift trees and logs had to be removed from the tramways.

The freshet carried down a great deal of silt, and I am told deposited considerable on the bar in the river just below Toledo.

A new quarters for the assistant engineer was built during the winter on the light-house reservation at Newport.

No survey of the bar was made during the last fiscal year.

No marked change has taken place. The Oregon Development Company's steamers have made their regular trips without delay.

Very respectfully,

J. S. POLHEMUS,
Assistant Engineer.

Capt. THOMAS W. SYMONS,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The following letter of Mr. J. S. Polhemus, and statement of Mr. William. M. Hoag, indicate the commerce passing over the Yaquina Bar:

NEWPORT, OREGON, *June* 18, 1890.

SIR: In reply to your letter of the 28th ultimo, relating to commercial statistics, I beg to say that I inclose herewith a list of the exports and imports carried by the Oregon Development Company's steamers from and to Yaquina Bay, furnished me by Mr. William M. Hoag.

The two vessels which carried this freight are the *Willamette Valley*, owned by the Oregon Development Company, and the *Farallon*, chartered. The *Willamette Valley* carried about 1,000 tons of cargo, and the *Farallon* about half as much. They draw when loaded from 12 to 14 feet.

The only other vessel employed in carrying freight to and from the bay during the fiscal year was the steam-schooner *Mischief*, with a carrying capacity of 2,000 cases of salmon, equal to 70 tons. She made voyages when cargoes offered, and weather permitted, throughout the year up to two months ago, bringing salmon, shingles, wool, hides, etc., from the Siuslaw and Alsea bays to Yaquina, and taking general merchandise as return cargo. She did not clear from custom-house, and has now gone to Alaska, and I can find no record of her freights, but I would estimate she made twenty-five round trips during the year, and carried 50 tons at a load. I think this freight is all accounted for in the Oregon Development Company's statement. The *Mischief* draws 8½ feet loaded.

No vessels were built here during the fiscal year.

Only one steam-boat runs on the bay and river, viz, the *T. M. Richardson*, which makes two round trips a day between Newport and Yaquina City, 4 miles apart, and

carries passengers and general merchandise to Newport. I could not find out what she carried. She is only a small boat 60 feet long, allowed to carry 100 passengers.

Only one accident occurred on the bar during the year, viz: On December 24, 1889, the steamer *Farallon* was boarded by a large breaker while crossing out over the bar, and five men washed overboard and two lost. Her house was stove in, and the engine room flooded and fires put out. She was towed back and repaired.

The Oregon Development Company's steamers carried during the year 778 incoming passengers and 456 outgoing.

Very respectfully,

J. S. POLHEMUS,
Assistant Engineer.

Capt. THOMAS W. SYMONS,
Corps of Engineers, U. S. A.

PORT OF YAQUINA, OREGON.

Exports and imports from June 10, 1889, *to June* 10, 1890, *by vessels of the Oregon Development Company.*

Articles.	Tonnage.		
	Exports.	Imports.	Totals.
Grain (wheat, oats)	26,541	9	26,550
Mill stuffs (flour, etc.)	1,846	15	1,861
Fish and oysters	697	109	806
Potatoes	440	2	442
Fruit	24	27	51
Wool and hides	202	.....	202
Machinery	68	286	354
Live stock	253	.....	253
Lime and cement	.....	5	5
Miscellaneous, including hardware, groceries, clothing, etc	1,997	7,553	9,550
Total	32,008	8,006	40,074

Voyages, north bound	50
Voyages, south bound	50

This statement was furnished by Mr. William M. Hoag.

Yaquina Bay is in the collection district of Yaquina. Yaquina is the port of entry. The nearest light-house is at Cape Foulweather, 4½ miles north of the entrance. Yaquina Bay forms (with the Oregon Pacific Railroad) a competitive line from Portland and Willamette Valley to San Francisco.

SPECIAL REPORT ON IMPROVEMENT OF ENTRANCE TO YAQUINA BAY, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, January 13, 1890.

GENERAL: In answer to the communication of Senators Dolph and Mitchell in regard to Yaquina Bay, referred to me by indorsement for report December 26, 1889, I have the honor to submit the following report:

The Government work at Yaquina Bay, for the benefit of the harbor entrance, consists of a south jetty completed as to length in accordance with the approved project of the Board of Engineers of November 13, 1888, and of a north jetty which has been built for a little more than one-third of its projected length from the shore.

I estimate that to "surely complete and give the requisite strength and stability to the work according to the present project" with such modifications as seem justified by experience will cost fully $370,560.30.

THE SOUTH JETTY.

I send herewith tracings showing longitudinal section of the south jetty as it exists, with reference to high and low water lines and lines of sand along foot of north (channel) side of jetty, and along foot of south side of jetty. The tracing* also shows twenty cross-sections of the jetty tramway as built, and the jetty enrockment as actually existing in the latter part of December, 1889.

The jetty was considered as completed about November 1, 1889. Since then the jetty has settled into the sandy foundation and a quantity of stone has been washed down to either side. The stone (which is the best available) is rather soft and a portion has been lost by the constant abrasion to which it is subjected. The deepening of the channel by scour has also dropped in much stone.

It is evident to me that if this jetty is to be maintained as a high-tide jetty, it must be very materially strengthened by making it wider, and, when first built, considerably higher than ordinary high tide, to allow for settlement, displacement, and abrasion. Although the jetty crest is now approximately up to ordinary high-tide level, the waves and big seas pass entirely over it.

Upon the tracing sent herewith I have indicated what I think should be the approximate cross-sections of the jetty to give the requisite strength and stability to the work, to enable it to withstand the violence of the sea in its exposed condition, and to control in proper manner the tidal flows, and to prevent sand being carried over the jetty into the channel.

The outer 750 feet of the jetty is far more exposed than the remainder to the action of the breakers, and it is, in consequence, proposed to give it a stronger cross-section.

For this portion of the jetty the cross-section proposed for the enrockment is 30 feet in width at 5.4 feet above ordinary high water; or 12.5 feet above mean low water, with a slope on the channel side of 1 vertical to 3 horizontal to 2 feet below low water, and 1 vertical to 1 horizontal from 2 feet below low water to the bottom; and a slope on the shore or south side of 1 vertical to $1\frac{1}{2}$ horizontal to the low-water line, and a slope of 1 on 1 thence to the bottom.

This cross-section is believed to be about that which can be secured by dumping stone from the existing tramway and permitting it to settle into place under the influence of the waves. The remainder of the jetty will be more protected by sand which will pile up in rear of it, and not being so exposed the cross-section, it is believed, can be diminished to that shown on the remaining cross-section of the tracing herewith. This differs from that before described only in having a top width of 20 feet instead of 30 feet.

To hold and protect the shore end of the jetty with certainty, it is estimated that 12,000 tons of rock will be required.

In explanation of the estimate for the cost of the south jetty, it may be stated that the sandy shoals of the bay have completely encircled the wharf where the stone for the existing jetty has previously been received, and before work can be commenced it will be necessary to extend the tramway and build a new wharf at the bay channel. This extension should be made across the mud flat to a point well up the bay, where the bottom is soft and the channel deep and permanent, and the water comparatively smooth.

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* Omitted; printed in Senate Ex. Doc. No. 47, Fifty-first Congress, first session.

The derrick and engine are good, and would only have to be moved to the new site.

A good portion of the old jetty tramway was built in 1882, seven years ago, and has been subjected to much wet from the spray of the breakers. The life of the yellow fir in bridge structures and trestles is about nine years, and in this case is naturally shorter. Most of the tramway needs extensive repairs to make it safe for the locomotive. I think the piles, although somewhat decayed and eaten by the "teredo," could be made to last for two or three years more.

The haul being so much longer it would be advisable to purchase a new locomotive, and at least ten new dump-cars, larger, stronger, and more conveniently arranged than those at present at Yaquina. Three additional stone-scows should be built.

If the wharf approach is constructed by hired labor, one or two pile-driver scows should be built and pile-driver derricks, etc., provided. We have engines which could be used for a time for this work.

A fresh water supply for the new wharf would be required, including a new windmill. It will be necessary to build a new ways and repair the old scows.

With the plant on hand and recommended in this report, it would require about a year to do this work.

THE NORTH JETTY.

In constructing the north jetty so far it has been found necessary to use more rock than just sufficient to bring it up to the level of half-tide, as projected by the Board of Engineers. This was necessary in order to protect the jetty tramway, many of the piles of which have very little holding in the sand and rock composing the bed.

For this reason and in order that the jetty may remain permanently at the elevation of half-tide, allowing for settlement, displacement, and abrasion, it will be advisable to build it in the first place to the level of high tide.

I submit herewith a tracing * showing the cross-section which, in my opinion, the jetty should have "to give the requisite strength and stability to the work according to the present project."

For the outer 750 feet of the north jetty it is proposed that the cross-section shall be similar to that for the outer 750 feet of the south jetty, having a width on top at high-water line when completed of 30 feet.

The other 930 feet yet untouched to have a similar cross-section, but diminishing in width so that at the present end of the jetty the width shall be 20 feet, which 20-foot width shall continue to the shore end.

The further extension of the north jetty tramway will be attended with great difficulties and many uncertainties, and these will increase as the jetty progresses, owing to the deeper and rougher water and the rocky bed which is of varying hardness. Many delays and contingencies are liable to occur to a work in such an exposed situation, and much will depend upon the character of the bed-rock met with.

In order to provide for reasonable contingencies the estimate for the construction of this tramway is made liberal and is, for the first 500 feet, $6 per foot, for the next 500 feet, $7.20 per foot, and for the remaining 680 feet, $9.60 per foot.

In further explanation of the estimate of the cost of completing the north jetty, submitted herewith, it may be mentioned that it will be nec-

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* Omitted; printed in Senate Ex. Doc., No. 47, Fifty-first Congress, first session.

essary to overhaul the pile-driver and provide a heavier hammer and stronger hoisting engine, and construct a new and stronger pile-driver derrick.

Three new stone-scows should be built, a little larger than those now on hand, some of which are old and are becoming unfit for service. Twenty new stone boxes, to be loaded on the scows with the largest pieces of stone, should be constructed.

Water should be brought from the Government tank to the wharf in an inch-and-a-half galvanized pipe. At present the water for boilers, boats, etc., is supplied by the water company of the city of Newport, and this supply is limited and uncertain.

It will require about 10,000 tons of stone to complete the existing portion of the jetty in accordance with the cross-section submitted herewith. In making the estimate for the stone required for the balance of the jetty, the average depth of the bed-rock below the plane of M. L. L. water is assumed at 10 feet. Where the jetty now ends this depth is 6 feet; at the outer end of the projected jetty it is over 12 feet. As the jetty advances all the sand from in front of it is scoured away, making it necessary to drive the piles in all cases into the bed-rock.

Estimated cost to complete the work at Yaquina Bay according to present project.

SOUTH JETTY.

Building three new stone-scows, at $2,500	$7,500.00
One pile-driver, scow derrick, etc	1,200.00
One hoisting engine	1,325.00
One derrick at quarry	700.00
Ten new dump-cars, at $500	5,000.00
Water supply for new wharf	1,500.00
Shifting derrick and engine to new wharf	150,00
Building new wharf, 40 feet by 120 feet	2,000.00
Building 4,400 feet of track trestle to new wharf, complete, with track, at $4.50	19,800.00
Repairing 3,000 feet of old tramway, at $2	6,000.00
Rails and fittings for double tracking south jetty tramway, 5,000 feet of track, at 60 cents	3,000,00
Placing on spur and shore extension of jetty 12,000 tons of stone, at $1.50	18,000.00
Placing on 3,000 feet of main jetty 60,000 tons of stone in pieces from 100 pounds to 6 tons (averaging 2 tons), at $1.50	90,000.00
Contingencies, engineering, superintendence, rents, etc., 10 per cent	15,617.50
Total	171,792.50

NORTH JETTY.

Building three new stone-scows, at $2,500	7,500.00
Two hoisting engines, at 1,325	2,650.00
One 10-ton locomotive	4,000.00
Two derricks, at $700	1,400.00
Ten new dump-cars, at $500	5,000.00
One 3,000-pound pile-driver hammer, at 4 cents	120.00
Repairing jetty pile-driver	600.00
Perfecting water supply at Newport, 2,000 feet of pipe and laying same, at 30 cents	600.00
Twenty new stone boxes, at $25	500.00
Building quarters at Cannon quarry	1,200.00
Purchase of new tools and supplies	3,000.00
Constructing jetty tramway 1,680 feet long—first 500 feet at $6, second 500 feet at $7.20, and the remaining 680 feet at $9.80	13,128.00
Placing on existing 1,050 feet of jetty and shore trestles 10,000 tons of stone, at $1.50	15,000.00
Extending jetty enrockment, 84,000 tons of stone, at $1.50	126,000.00
Contingencies, engineering, etc., 10 per cent	18,069.80
Total	198,767.80
Total estimated cost of both jetties	370,560.30

Of this amount there can be profitably expended during the next fiscal year $250,000.

This would enable all auxiliary operations incident to the vigorous prosecution of the work to be done and about two-thirds of the rock to be put into position.

It is possible that as the work advances it will be found practicable to reduce the cross-section of the enrockment proposed, and yet retain sufficient strength to resist the action of the sea, thereby reducing the ultimate cost.

With this in view it will be well to carry on the work as much as possible along the entire length of the jetties, and to stop it when more mature judgment, born of further experience, indicates that they "surely have the requisite strength and stability."

In regard to the latter part of this letter of Senators Dolph and Mitchell, which states "we should be gratified if the officers in charge be requested to submit to your judgment his views upon the feasibility of making such a channel as will allow the exit of vessels drawing 25 feet of water, and what additional appropriation would be sufficient to attain this result," I have the honor to report as follows:

I do not think that sufficient experience has been had with this harbor or with harbors of this kind to permit views in the case to be formed by me which would be at all satisfactory or conclusive even to my own mind.

In order that ships may enter and leave the harbor safely drawing 25 feet of water, there should be about 30 feet of water on the bar at high tide, or 23 feet at low tide. The records of this office show that there is rock underlying the bar sand of the proposed harbor entrance at various elevations of from 18 to 31 feet below the plane of low water. The general average elevation of this underlying rock would be about 21 or 22 feet below the plane of low water.

If all the sand were scoured off the bar the least depth at high water would be, as far as known, 25 feet, average depth about 29 feet, and greatest depth about 38 feet.

The object of the jetties built and protected is to cause this scour to take place to as great an extent as possible, and the most that can be hoped from them or their possible extensions in the future would be to scour this bar sand away and keep it away, leaving the rocky bottom exposed. Then, and then only, could a determination be made of the amount and character of the rock to be removed to reduce the rock bottom to a depth of 23 feet below low water, and a satisfactory judgment be formed as to the feasibility of keeping it to this depth, and an estimate of the cost of the work made.

Such being the case, I conceive that the time has not yet arrived for the formation of any definite views or judgment in the matter, and I am unable to make any satisfactory estimate of the additional appropriation sufficient to attain the result, *i. e.*, to permit the exit of vessels drawing 25 feet of water.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

T T 5.

IMPROVEMENT OF TILLAMOOK BAY AND BAR, OREGON.

DESCRIPTION OF ORIGINAL CONDITION.

The channel over the bar is direct and shifts but little, so that the bar is considered one of the safest on the Oregon coast. A fair depth of water is maintained throughout most of the year, and vessels drawing as much as 13 feet can usually enter without difficulty. The bay, at low, tide, consists of three channels, running through sand and mud flats. These channels are of fair depth near the entrance but gradually shoal up, giving depths of only 1 or 2 feet near the head of the bay. Tillamook, the principal town of the region, is situated on a tidal slough above the head of the bay, and can be reached only by light-draught vessels at high tide.

PLAN OF IMPROVEMENT.

No general plan and project for the improvement of the bay and bar has yet been approved. A special project for the expenditure of the money appropriated by the act of August 11, 1888, has been approved. This consisted in making a survey of the bar and entrance and the construction of longitudinal and spur-dikes and shore-protection works to deepen the water over Dry Stocking Bar, at the mouth of Hoquarton Slough, and to remove snags and overhanging trees from Hoquarton Slough.

APPROPRIATIONS.

Act of August 11, 1888	$5,200.00
Amount expended to June 30, 1889	47.78

RESULTS OBTAINED TO JUNE 30, 1889.

No work except of a preliminary character was done and no results obtained.

Amount expended during year ending June 30, 1890, was $4,687.77.

RESULTS OBTAINED TO JUNE 30, 1890.

During the year 1,148.5 feet of sheet-pile dikes and 448.5 feet of pile and brush revetment work were built at Dry Stocking Bar. But the unprecedented freshets of the past winter and spring swept them away, so that no results can be claimed for the work done.

REPORT OF OPERATIONS.

Report of operations for fiscal year ending June 30, 1890, improving Tillamook Bay and Bar, Oregon.

During the year 1,148.5 feet of sheet-pile dikes and 448.5 feet of pile and brush revetment work were construced at Dry Stocking Bar. The sheet-pile dikes consisted of 944 feet of longitudinal dike, with three spurs 75 feet, and two spur-dikes from the shore 129½ feet. The notes of the survey of the bar and entrance, which were made in June, 1889, were plotted, and the result submitted to the Department February 18, 1890. Hoquarton Slough was cleared of snags as far as Tillamook City. A break of 80 feet in the longitudinal dike, which occurred Sep-

tember 30, 1889, was repaired. During the high water of November and December, 1889, the greater portion of the longitudinal dike was carried away, together with the three spur-dikes adjacent thereto. A plan for the repair of the break was submitted, and further operations were suspended until funds sufficient therefor should be appropriated by Congress.

RECOMMENDATIONS AND REMARKS.

Experience shows that the dikes constructed at Dry Stocking Bar were wholly inadequate in strength for the work required of them. The construction of these dikes is the only approved project for the improvement of the waters of Tillamook Bay, and it is estimated that to build longitudinal and spur-dikes and shore-protection works for deepening the water across Dry Stocking Bar will cost $6,000.

FUTURE OPERATIONS.

Future operations will consist in replacement of these dikes, as required by the present approved project as soon as money is available therefor.

Money statement.

July 1, 1889, amount available	$1,483.41
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,018.95
July 1, 1890, balance available	464.46
Amount appropriated by act of September 19, 1890	500.00
Amount available for fiscal year ending June 30, 1891	964.46
Amount (estimated) required for completion of existing project	5,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	5,500.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

Tillamook Bay is in the collection district of Oregon. Astoria, near the mouth of the Columbia River, is the nearest port of entry. The nearest light-house is at Cape Meares, about 4 miles south of the entrance. The shipments from Tillamook are salmon, lumber, beef, wool, and dairy products.

The following returns are furnished by Mr. Charles Lamb, of Tillamook, for the year ending June 30, 1890, but are only partial, on account of the many changes made in ownership of the different establishments.

Steam-schooners, 8; steam-tug, 1; steam-scow, 1; average tonnage, 200. Vessels arrived, 84; vessels cleared, 84; average tonnage, 948.

Draught of vessels when loaded, from 7½ to 13½ feet.

The passenger travel was very light, aggregating about 250 for the year.

Imports and exports.

IMPORTS.

Articles.	Quantity.	Articles.	Quantity.
General merchandise.....tons..	1,960	Mill machinery.....tons..	30
Agricultural implements.....do...	25	Steam-boat boiler .....do...	1
		Total .....tons..	2,016

Imports and exports—Continued.

EXPORTS.

Articles.	Quantity.	Articles.	Quantity.
Lumber ..... tons..	25,375.0	Wool ..... tons..	3.0
Salmon (canned) ..... do...	312.5	Cheese ..... do...	1.0
Salmon (salt) ..... do...	13.3	General merchandise ..... do...	30.0
Butter ..... do...	8.0		
Hides (beef) ..... do...	12.0	Total	25,755.8
Hides (sheep) ..... do...	1.0		

The only accident of note happening was to the steam-ship *South Coast*, about June 18, 1889, in crossing out over the bar. She struck and carried away her rudder; she left the bay just prior to high tide, drawing 14½ feet, and struck about midway over. The masters on the different steamers report from 18 feet to 25 feet on crossing the bar.

T T 6.

IMPROVEMENT OF UPPER COLUMBIA AND SNAKE RIVERS, OREGON AND WASHINGTON.

DESCRIPTION OF ORIGINAL CONDITION.

Under the above head it has been deemed proper to officially include the continuous Columbia and Snake rivers from Celilo at the head of the Dalles to Lewiston.

A special survey and project having been made for that portion of the Upper Columbia between Wallula and the British line, that portion is not considered in this report, except the small extent of the Columbia between Wallula and the mouth of the Snake.

The Upper Columbia and Snake form a continuous line of navigable rivers, but broken by many rapids, rendering navigation difficult and dangerous.

These rapids are in nearly every instance caused by rocky bars with occasional bowlders, and the channels were crooked and narrow.

Before improvement the ruling depth at low water was 2 to 3 feet on many of these bars; some of which were practically impassable at low water.

The *Colonel Wright*, 302 tons, built in 1888, was the first steamer to run between Celilo and Lewiston; since them many other steamers have run on the route.

PLAN OF IMPROVEMENT.

Previous to 1877 $120,000 had been appropriated for the work of improvement, and had been expended in survey and rock removal at the principal rapids.

In 1877, Maj. J. M. Wilson made a project for the improvement of the Upper Columbia and Snake rivers, consisting of removing rock bowlders and rocky reefs, and scraping gravel bars to secure a low-water channel of 5½ feet in the Columbia as far as the mouth of the Snake, and 4½ feet in the Snake as far as Lewiston. The estimated cost of this work was $132,000.

APPROPRIATIONS.

Upper Columbia River—	
Act June 10, 1873	$50,000
Act June 23, 1874	20,000
Act March 3, 1885	35,000
Total	105,000
Upper Columbia and Snake rivers—	
Act August 14, 1876	15,000
Act June 18, 1878	20,000
Act March 3, 1879	20,000
Act June 14, 1880	15,000
Act March 3, 1881	15,000
Act August 2, 1882	6,000
Act July 5, 1884	20,000
Act August 5, 1886	10,000
Act August 11, 1888	10,000
Total	131,000
Aggregate	236,000

Amount expended on project to June 30, 1889, was $129,704.39.

RESULTS OBTAINED JUNE 30, 1889.

Maj. W. A. Jones in his last annual report says: Snake River between Lewiston and the mouth has ordinary widths of 1,000 feet, a slope of 2.48 feet per mile, and a discharge of 26,000 cubic feet per second. All the bars have been improved to the extent of being no longer dangerous to competent navigators who are acquainted with them, and, with the exception of Long Crossing Bar on the Snake, the required depth below the datum assumed at the time our project was adopted has been obtained. This datum, however, has been lowered about 1½ feet, so that the ruling low-water depth on Snake River outside of Long Crossing Bar is now 3 feet. This depth I consider sufficient for present purposes.

AMOUNT EXPENDED DURING YEAR ENDING JUNE 30, 1890.

Expended during year ending June 30, 1890, $991.36, the larger portion of which was expended in paying outstanding liabilities incurred previous to beginning of the year.

RESULTS OBTAINED TO JUNE 30, 1890.

There has been no change in the results obtained since the last annual report.

REPORT OF OPERATIONS.

No operation beyond the care of the plant was carried on during the year.

RECOMMENDATIONS AND REMARKS.

The above letter from Mr. C. J. Smith shows that the only portion of the river under consideration which is navigated is that portion of the Snake between Lewiston and Riparia. Such being the case, I recommend that future operations be confined to this portion of the river, at any rate for the present, and that this portion of the river, which is in

the center of the most fertile regions of eastern Washington, be put in as good a navigable condition as possible. An estimate for $25,000 for this is made; this to be expended in removing rocks and shoals.

FUTURE OPERATIONS.

Future operations will be confined, in all probability, to the removal of rocks and gravel bars in the navigated portion of the river.

Money statement.

July 1, 1889, amount available		$905.38
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$601.13	
July 1, 1890, outstanding liabilities	23.00	
		624.13
July 1, 1890, balance available		281.25
Amount appropriated by act of September 19, 1890		20,000.00
Amount available for fiscal year ending June 30, 1891		20,281.25
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		25,000.00

COMMERCIAL STATISTICS.

The following letter from Mr. C. J. Smith, general manager of the Union Pacific System (lessees of the Oregon Railway and Navigation Company) gives a clear synopsis of the commercial statistics.

PORTLAND, OREGON, *June* 10, 1890.

MY DEAR SIR: Replying to inquiries in your letter of June 7, asking information in regard to navigation of the Upper Columbia and Snake rivers between Celilo and Lewiston.

We have not for a number of years past operated the river between Celilo and Riparia with steam-boats. Our work has been entirely between Riparia and Lewiston, a distance of about 70 miles, with occasional trips from Lewiston up to what is known as Goose Rapids, about 25 miles on the Snake River, and from Lewiston to what is known as Pine Bluffs, about 35 miles on the Clearwater River. The steam-boats that we have used in this service are as follows: *Annie Faxon, John Gates, Almota, Spokane.*

During the past year there was an almost entire failure of the wheat crop along the Snake River. In consequence, the amount of tonnage taken out of Snake River was very light. Under ordinary circumstances, the tonnage received by steamers at Riparia, originating at points along the Snake and Clearwater Rivers, would amount to about 25,000 tons. During the year 1889, owing to the failure of crops, the amount received was but 4,515 tons. The amount delivered to the boats at Riparia, and distributed by them to points along the Snake River, was 1,823 tons.

It is a difficult matter to operate the Snake River below Riparia, owing to the number of rapids and to the low water. In consequence of this, we have entirely abandoned the Snake River below Riparia.

With reference to navigation above Riparia, I would say that there is a large agricultural country that is entirely dependent upon this means of transportation for themselves and their supplies, and I think it desirable that the Government should expend some money at points between Riparia and Lewiston, especially in deepening the water at several of the rapids, so that light-draught boats may have a longer period of transportation during the year. I can, if you desire it, ascertain and advise you of the exact points where it is desirable to have a removal of rocks in the rapids, and statements from the captains employed upon the steam-boats as to the best time and method of reaching the obstructions. I do not volunteer this, as I suppose it to be a matter that you are familiar with.

Going further up the Snake, I would say that there is a steamer now being built, and about finished, that expects to ply on the waters of the Snake between the crossing of that river near Huntington, Oregon, by the Oregon Short Line and Utah North-

ern Railway, and thence running down the Snake to what is known as the Seven Devils country, a distance of about 65 miles. This boat will furnish transportation to a mining region that is not developed to any extent, but the prospects for which are very great. They have already contracted for transportation from this district for 6,000 tons of ore during the season of 1890. There has been a great delay in the settlement and development of this country, owing to a lack of transportation facilities. With the placing of this steamer on the river, there is every indication of a heavy development of the mines tributary to the river and a considerable movement of passengers and freight going into the country. If there has not as yet been a survey made by the Government, looking to the improvement of navigation on this particular stretch of the Snake River, I should consider it very desirable. This company has no interest in the steam-boat transportation at this point, and I have therefore no definite knowledge of the amount of water in the river at the various seasons of the year, or the obstructions to navigation. I am acquainted, however, with the captain of the boat. It is expected the boat will start running about the 1st of July, and I can either give you a letter to him or ask him for definite details, to be transmitted to your office, as you prefer.

Yours, truly,

C. J. SMITH,
General Manager.

Capt. THOMAS W. SYMONS,
Corps of Engineers, U. S. A.

T T 7.

IMPROVEMENT OF THE CHEHALIS RIVER, WASHINGTON.

DESCRIPTION OF ORIGINAL CONDITION.

The navigable portion of the Chehalis River is about 90 miles in length from Claquato to its mouth. This may well be considered in three sections.

First. From the mouth to Montesano, a distance of 12 miles, there is about 18 feet of water at high water, and coasting vessels traverse this portion of the river.

Second. From Montesano to Elma, 16 miles, the river is affected by the tides, and has sufficient water for a channel all the year round. But navigation is obstructed by logs and fallen trees.

Third. Above Elma, the river is practically blockaded during the summer and fall by snags, shoals, and a general lack of water. At this time the river is a succession of shoals and pools. On many of the shoals the depth is reported to be only from 6 to 12 inches.

PLAN OF IMPROVEMENT.

The plan of improvement contemplates removal of snags, overhanging trees, jams, drift heaps, shoals, and other obstructions to navigation.

APPROPRIATIONS.

August 2, 1882	$3,000
July 5, 1884	2,500
August 5, 1886	2,500
August 11, 1888	2,000
Total	10,000

Amount expended to June 30, 1889, was $8,667.14.

RESULTS OBTAINED TO JUNE 30, 1889.

During the year ending June 30, 1889, sixty snags and five overhanging trees were removed, and navigation to this extent improved. From

the nature of the work no results of a permanent nature affecting the regimen of the river was obtained.

Amount expended during fiscal year ending June 30, 1890, was $1,006.77.

RESULTS OBTAINED TO JUNE 30, 1890.

During the year fifty-six snags were removed, and the navigation of the river rendered safer thereby.

OPERATIONS DURING THE YEAR.

At the beginning of the fiscal year, July 1,1889, there was available for work on this river the sum of $1,332.86.

The steamer *Aberdeen*, Capt. Thomas S. Tew, was employed to pull snags and remove obstructions. This steamer had been fitted up with hoisting engine and the necessary appliances the year before. The price paid was $31.67 per day for this steamer, and the crew paid by the United States.

Actual operations with the boat were confined to twenty days in September, during which time fifty-six snags were removed from the reach of the river between Aberdeen and Elma, most of them being taken from just below Montesano. The money available was not sufficient to thoroughly open up the river.

The following letter from Mr. G. H. Emerson, manager of the Northwestern Lumber Company, indicates that this river has very considerable commerce and needs larger appropriations to keep it open in a satisfactory manner:

HOQUIAM, WASH., *May* 22, 1890.

DEAR SIR: Yours of May 12 is at hand. The expenditures for Government appropriations on the Chehalis River thus far have been made above Montesano, and as there has probably been not in excess of six trips with any steamer during the past year to any point above the obstructions that have been removed, it is difficult to say exactly how the improvements have benefited navigation, except for saw-logs. There is, however, and has been great necessity for the removal of snags between Cosmopolis and Montesano from that portion of the river over which regular lines of steamers are now making eight trips per day, and ocean-going vessels are passing at intervals. There is also necessity for the removal of three shoals in the Chehalis, between Cosmopolis and Montesano, which, if removed, together with the snags indicated, would allow any vessel now entering Gray's Harbor to reach that point. In the harbor proper there exists two more shoals; one between Hoquiam and Aberdeen and one between Hoquiam and Gray's Harbor, which should also be deepened.

* * * * * * *

Maj. T. H. HANDBURY,
Corps of Engineers, U. S. A.

It is estimated that an appropriation of $10,000 could be profitably expended on the Chehalis River during the fiscal year ending June 30, 1892.

COMMERCIAL STATISTICS.

Chehalis River is in the collection district of Oregon. The nearest light-house is on Toke Point, at the entrance to Shoalwater Bay, 16 miles south of Gray's Harbor, into which the river empties.

The two principal places on the Chehalis, Aberdeen and Montesano, each received during the past year about 2,700 tons of merchandise by water, and shipped about 20,000,000 feet of lumber.

Cosmopolis received about 900 tons of merchandise, and shipped about 12,000,000 of lumber.

Local passenger and freight steamers make eight trips per day between Cosmopolis and Montesano.

Money statement.

July 1, 1889, amount available	$1,332.86
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,006.77
July 1, 1890, balance available	326.09
Amount appropriated by act of September 19, 1890	3,000.00
Amount available for fiscal year ending June 30, 1891	3,326.09
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	10,000.00

T T 8.

IMPROVEMENT OF SKAGIT, STEILAQUAMISH, NOOTSACK, SNOHOMISH, AND SNOQUALMIE RIVERS, WASHINGTON.

DESCRIPTION OF ORIGINAL CONDITION.

The waters of these rivers all rise in the Cascade Range, and flow to the west into Puget Sound, between the forty-eighth and forty-ninth parallels of latitude.

In their original condition they carried water enough for the purpose of steamer navigation, but were obstructed by snags, fallen trees, and log jams. They were the great highways of the country, traveling on land being almost impossible on account of the heavy timber, dense underbrush, and fallen logs.

The Snoqualmie is a branch of the Snohomish.

The aggregate length of all is estimated to be about 250 miles.

PLAN OF IMPROVEMENT.

The plan of improvement contemplates the removal of snags, logs, trees, and other obstructions to their navigation. For this purpose a snag-boat with an outfit of tools and appliances has been provided. This boat passes from one river to another, doing service in each as far as the necessities of its commerce require and the amount of the funds appropriated will admit.

With the funds that have been appropriated, this snag-boat and outfit have been provided and a large number of snags, jams, overhanging trees, and other obstructions to their navigation removed. These, with the trees that from time to time fall into the rivers, will furnish constant employment for the snag-boat for several seasons.

APPROPRIATIONS.

June 14, 1880	$2,500
August 2, 1882	20,000
July 5, 1884	10,000
August 5, 1886	10,000
August 11, 1888	15,000
Total	57,500

RESULTS OBTAINED.

In this class of work no permanent results are arrived at or obtained. The constantly recurring snags and fallen trees, etc., are required to be constantly removed. The rivers have been kept open for navigation, and many of the perils of navigation have been removed.

REPORT OF OPERATIONS.

There were no operations during the year beyond taking care of the plant and putting it in shape for future operations.

RECOMMENDATIONS AND REMARKS.

The State of Washington has made remarkable advance in recent years, and this is especially the case with the regions about Puget Sound. The growth and development of those regions have been largely aided by the improvement of the navigation of these rivers traversing the country between Puget Sound and the Cascade Mountains.

These water-ways are of great importance on account of the extreme difficulty of penetrating with roads of any kind the dense and tangled forests and broken country between them. The difficulties of traversing those regions away from the rivers can scarcely be imagined by one unfamiliar with the country.

The development of the country has increased the number of steamers traversing the rivers, and their commercial importance, and therewith the necessity for more work being done to open and keep them open.

It would seem to be the part of wisdom to not only provide ample funds to keep the snag-boat *Skagit* in operation whenever the condition of the rivers will permit, but also to provide funds for separate parties engaged in clearing the river from drifts, log jams, overhanging trees, rocks, etc.

I recommend an appropriation of $30,000 for these rivers for the fiscal year 1891–'92.

FUTURE OPERATIONS.

Future operations it is expected will be confined to keeping the snag-boat in good condition, providing her with steam-steering gear and metal water tanks, and to operating her on these rivers in the removal of obstructions as heretofore.

Money statement.

July 1, 1889, amount available	$4,117.90
July 1, 1890, amount expended during fiscal year, exclusive of liabilities standing July 1, 1889	813.07
July 1, 1890, balance available	3,304.83
Amount appropriated by act of September 19, 1890	12,000.00
Amount available for fiscal year ending June 30, 1891	15,304.83
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	30,000.00

COMMERCIAL STATISTICS.

The following letter from Mr. E. H. Jefferson contains valuable general data concerning these rivers, and the only commercial statistics obtainable.

Mr. Jefferson has for a number of years been in charge of the Skagit.

SEATTLE, WASH., *June* 17, 1890.

SIR: In compliance with your request of the 2d instant for certain data bearing upon the commerce and importance of the Puget Sound rivers, I have the honor to submit the following, which I think is approximately correct:

The Skagit River is navigable a distance of 110 miles, but not that far at all stages of water. The principal towns or stopping places are, first, Fir, 4 miles from the mouth; population about 50; next is Skagit City, 8 miles from the mouth, with a population of about 50; then comes Mount Vernon, 12 miles from the entrance, with about 800 inhabitants; Avon, 16 miles up, has a population of 250; Sears, 28 miles up, has about 500 people; Lyman, 38 miles from the mouth, has about 25 population; Hamilton, 44 miles up, contains about 450, and is now growing quite fast; Bird's View, 52 miles up, has a population of about 20; Sauk, 85 miles from the mouth, has 25 people. Logging camps and settlers are located at different points, both above and below the last-named place, of whose numbers it is difficult to estimate.

The Steilaquamish River is navigable for about 25 miles at certain stages of water, but ordinarily 6 or 8 miles only for the class of boats that carry the bulk of the freight for points on that river, they discharging it at Stanwood, near the mouth, from where it is transported to up-river points by wagons and canoes at an average charge of $10 per ton. Occasionally, when the stage of water is favorable, a small steamer will load for up-river points.

The first town at mouth of the river and on the direct route of the Skagit River steamers is Stanwood, with a population of 500; next is Florence, 6 miles up, containing about 150; at the "foot of the island," 12 miles up, is a small place containing a post-office, school-house, store, and hotel; about 30 people are here. At "the Forks," 25 miles from the mouth, are two new town-sites, Haller City and Arlington, and it is estimated that between 500 and 1,000 people are congregated there at present. The Seattle, Lake Shore and Eastern Railway are bridging the stream at that point, and Seattle and Montana Railway expects to cross near by. There are logging camps along this river, and 5 small saw-mills, also 1 shingle mill. The logging camps contain from 20 to 30 men each.

The Snohomish river is navigable to the forks of the Skikomish and Snoqualmie, a distance of 27 miles, except at very low stages of water, but at all times as far as Snohomish City (18 miles up).

Marysville is first town, 2½ miles from the mouth, and has 150 inhabitants; Lowell comes next, 8 miles up, with a population of about 75; Snohomish City is 18 miles from the entrance, and contains about 1,800 inhabitants. Large quantities of lumber and shingles are manufactured there. The Seattle, Lake Shore and Eastern Railway crosses the river there.

The Snoqualmie River is a branch of the Snohomish, and is navigable for 35 miles to Falls City for quite small steamers when the stage of water will permit. Falls City is the only town of any consequence, containing about 30 people, but there are several landing places where supplies are unloaded for settlers and loggers, and where produce is taken on board. The Seattle, Lake Shore and Eastern Railway taps the upper waters of this stream. The Nooksack River is navigable 45 miles; at its mouth is the town and post-office called Lummi, containing about 140 people. The Lummi Indian Reservation is also near by, with church, school-house, etc., and containing 100 or so Indians. The town of Ferndale is 12 miles up with a population of 150. Lynden is 25 miles from the mouth, and has about 450 population, and is as far as steamers have been in the habit of ascending, as just above that point there has existed for many years an obstruction jam of drift and logs upon which the Government and private parties also have done considerable work. There has always been a difference of opinion among the settlers at that point about the way and manner of clearing the said obstruction, as an island divides the river thus making two channels, and as both were obstructed, interested settlers persist in endeavoring to keep the one flowing by their particular lands from being opened, with the view of preventing their land from eroding and washing away.

The town of Nooksack, or more familiarly known as "The Crossing," is about 40 miles from the river's mouth, and its population can be estimated anywhere from 200 to 500, as it is constantly increasing by reason of railroad building in its vicinity. The railroad is contemplating a crossing at that point, while another one is reported as intending to cross at Ferndale, lower down.

The river between Lynden and Nooksack is shoal, and can only be navigated by small steamers at proper stages of water. There has never been one above the former place since the date of my knowledge of the stream.

Plying on the Skagit River, the regular steamers are: The *Henry Bailey*, 209 tons; *W. F. Munro*, 100 tons; *Cascade*, 65 tons, and the *Indiana*, 82 tons. The three former run from Seattle, and the latter plies between Mount Vernon and the head of navigation. The three first-named all stop regularly at Stanwood, at mouth of the Steilaquamish.

On the Steilaquamish River the only regular boat plying above Stanwood is a little naphtha launch, called *The Pet.*

On the Snohomish the *Mabel*, 114 tons, is the only regular steamer; another one, probably the *City of Quincy*, 120 tons, will be put on soon.

On the Snoqualmie the steamer *Mamie*, 43 tons, makes regular trips.

On the Nooksack the *Triumph*, 67 tons, *Adventure*, 45 tons, and the *Edith*, 40 tons, run regularly.

All of these steamers (except the *Pet*, which is a propeller) are stern-wheelers. In addition to those named there are other boats that make frequent trips with loads of supplies to the various logging camps.

I find it a very difficult matter to get any correct information as to the amount of freight carried by these steamers; all interested seem to be adverse to giving any definite figures, or disclosing the secrets of their business.

It is simply impossible to segregate the articles of freight carried and get a statement of the number of tons of each, but from information gained by persistent inquiry and from various sources I am enabled to give the following figures, which I am satisfied is rather under than over the actual amount.

The average amount of freight carried by the regular boats to the different river points per month is 4,800 tons; this consists of flour, ground feed, hardware, furniture, and general merchandise. The average per month of return freight is 2,700 tons, which consists principally of hay, grain, shingles, butter, eggs, fruit, etc.

Of this amount, 2,850 tons can be credited to the Skagit; 2,400 tons to the Snohomish, and the Snoqualmie; 1,350 tons to the Steilaquamish, and 900 tons to the Nootsack River. This does not include occasional loads carried by irregular boats, the amount of which I could get no definite information.

As to the general effect of work already done on these rivers, I beg to state that it has been beneficial in many ways and helped to develop the country, by rendering it more easy of access, making the navigation of them safer so they can be run of nights, facilitated the handling of logs in booms and rafts, caused the removal of large drift-jams, thus lessening the overflow of lands, and in some instances caused a reduction in freight rates.

In regard to the amount that can be profitably used in improvement of these rivers, I will say that if $12,000 could be secured, *every* year, it would probably be sufficient to keep the snag-boat in commission most of the time, but as Congress fails to pass a river and harbor bill every short session, the boat for want of funds is compelled to lie idle about half the time, and very often when the rivers need her the most, and when her work could be most effective.

If larger amounts were asked for, and obtained, I am sure that the funds could be profitably expended. A more liberal use of explosives could be made, and in some cases a few piles driven with a deposit of brush and stone would greatly benefit the channel at the entrance to some of the streams.

Two or three freshets per year occur in the river and generally leave them in a bad condition by reason of the banks washing freely and letting in great numbers of trees and stumps, some of them of the largest kind, and they frequently remain in that condition until funds are again available to operate the snag-boat.

The universal cry of the steam-boat men and settlers is, "When is the snag-boat coming out again; she is needed badly," etc.

The snag-boat is nearly seven years old, and will soon need repairs as she grows older. When first built there were not funds to complete her as she should have been, or as was originally intended. A cabin was added about sixteen months ago; she needs other additions yet to make her what she should be, notably, metal water-tanks and patent steering gear.

Very respectfully,

E. H. JEFFERSON.

Capt. THOMAS W. SYMONS,
Corps of Engineers, U. S. A.

T T 9.

PRELIMINARY EXAMINATION OF YOUNG'S RIVER AND ITS TRIBUTARY, KLASKUINE RIVER, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, December 20, 1888.

GENERAL: I have the honor to report that the preliminary examination, specified in section 13 of the river and harbor act of August 11,

1888, of Young's River and its tributary, Klaskuine River, Oregon, has been made by me, in compliance with the instructions contained in the letter of the Chief of Engineers dated September 29, 1888.

In my opinion Young's River and its tributary, Klaskuine River, are worthy of improvement.

It is only in the tidal sections that these rivers may be considered as navigable streams. The principal obstructions to navigation lie above the mouth of the Klaskuine. The river below is about 9 miles in length, is from 300 to 1,000 feet or more in width, and is almost free from snags, having a good channel, with a least depth at low water of 6 feet. Above the mouth of the Klaskuine the tidal section of each stream is about 3 miles in length, and the channels are narrow and tortuous. Navigation here is rendered dangerous by drift, snags, and sunken logs. The available depths now at low water are from 2 to 3 feet. If the channels were cleared out the available depths would be at least 4 feet. The ordinary rise and fall of the tide is between 6 and 7 feet. This makes it possible for boats of considerable draught to navigate the streams in their present condition by taking advantage of the tide. One boat now makes regular trips on the rivers four times a week, going as far as the cut-off on Young's, a mile above the mouth of the Klaskuine, and as far up as Kamm's Wharf on the Klaskuine, or to within a few hundred yards of the head of tide. Occasional trips are made by other boats.

The improvement at present desired and asked for is, so far as I have been able to learn, that the streams shall be cleared of snags and drifts as far up as the Pulp-Mill on Young's River, which is about 2 miles above the mouth of the Klaskuine; and as far up as Kamm's Wharf on the Klaskuine; and that the cut-off on Young's River shall be dammed so as to confine the water to the old channel, or else that the old channel shall be dammed and the cut-off widened out so as to permit boats to pass. The cost of such an improvement will be small, while the benefits will be quite appreciable in the avoidance of dangers and delay; and in making available a magnificent water-power which exists at the Falls of Young's River, just above the head of tide. Already a pulp-mill has been started a mile or so below the falls for converting spruce and other timber into pulp, which is shipped to San Francisco and made into paper. A saw-mill is now talked of. Other enterprises may be expected to start up when the river shall have been opened.

There being few or no roads in this section of the country, the river is used as a highway by the settlers, and all their supplies are taken in and the produce brought out by boat. In this way a considerable trade has been carried on for years. The rich tide lands of the valley are being gradually reclaimed by diking, and the hill lands are being cleared and brought under cultivation. Large quantities of hay are shipped out, besides farm and dairy products, saw-logs, wood, and pulp.

Not a small part of the traffic over the Klaskuine is furnished by the Middle Nehalem Valley country, which is now being rapidly settled up. All travel and freight to and from this section now go by boat up Young's and Klaskuine rivers to Kamm's Wharf, and from there overland about 30 miles to the valley. The commerce of the rivers will increase in proportion to the growth of the tributary and adjacent country, which is of considerable extent and quite rich in natural resources. Statistics as to the amount and value of the present commerce are not available.

The cost of the improvement now asked for would not, I think, exceed $2,500. I estimate that it would cost $100 to make such an exam-

ination or survey as is needed to enable a report to be made, including a project, with a careful estimate of the cost of the improvement.

Very respectfully, your obedient servant,

W. YOUNG,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF YOUNG'S RIVER AND ITS TRIBUTARY, KLASKUINE RIVER, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, November 25, 1889.

GENERAL: In compliance with the instructions contained in your letter of April 1, 1889, I have the honor to transmit herewith a report of Mr. James S. Polhemus, assistant engineer on the survey of Young's River and its tributary, Klaskuine River, Oregon.

In my report of a preliminary examination of Young's River and its tributary, Klaskuine River, submitted December 22, 1888, I mentioned such points as I was enabled to ascertain by a personal examination and inquiry. These, in connection with the report of Mr. Polhemus, are considered sufficient to show the propriety of improving the river, since the expense will not be great, nor incommensurate with the probable benefits to result therefrom.

YOUNG'S RIVER.

The funds available for this survey were not sufficient to permit a hydrographic chart of the river to be made, nor was this considered necessary. A tracing* of the map prepared under the direction of Capt. C. F. Powell, Corps of Engineers, in 1881, is transmitted herewith for convenient reference.

PROPOSED PROJECT.

To remove the snags and sunken logs from the channel of Young's River as far up as the lower end of the "cut-off," and from the channel of Klaskuine River as far up as Kamm's Wharf; and to cut down all dangerous overhanging trees within the same limits.

ESTIMATED COST.

For removing snags from the channel of Young's River, in the lower reach, below the Klaskuine	$75
For removing snags and sunken logs, and cutting down overhanging trees from the mouth of Klaskuine River to the "cut-off" on Young's River	700
For removing snags and sunken logs and cutting down overhanging trees along the Klaskuine River as far up as Kamm's Wharf	600
Contingencies, 20 per cent	275
Total	1,650

*Omitted; printed in House Ex. Doc. No. 69, Fifty-first Congress, first session.

The above estimate is based upon the supposition that the work is to be done by one of the Government snag-boats now in service upon the Columbia and Willamette rivers.

Very respectfully, your obedient servant,

W. YOUNG,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. J. S. POLHEMUS, ASSISTANT ENGINEER.

NEWPORT, OREGON, *September* 1, 1889.

SIR: I have the honor to make the following report of a survey of Young's River, Oregon, and its tributary, the Klaskuine, made in August, 1889, in compliance with your instructions of July 29, 1889.

I left Newport August 13, and proceeded to Young's River via Portland and Astoria.

I spent two days on Young's River as far up as the pulp mill, and on the Klaskuine, taking soundings and noting the snags and other obstructions to navigation.

GENERAL DESCRIPTION OF THE RIVERS.

Young's River is joined by the Klaskuine at a point about 7 miles south of Astoria. By water it is 10 miles from Astoria via Columbia River and Young's Bay.

The 6 miles of Young's River from the Klaskuine to the bay is from 300 to 1,200 feet wide. The channel is practically free from obstructions, and has a least depth of 5 or 6 feet at low water, and requires no improvement, except the pulling out of the channel of two or three snags.

The average tidal range is 7 feet, which continues about the same up Young's River one-half mile above the "cut-off," and up the Klaskuine to Kamm's Wharf.

The banks of the stream are chiefly tide lands, a considerable area of which is being reclaimed by diking, when its great fertility renders it capable of producing large crops of hay, oats, roots, etc.

The distance on Young's River from the mouth of the Klaskuine to the extreme head of tide below the falls is about 2 miles. The channel is crooked and full of snags and sunken logs, especially in the upper reaches.

Steam-boats now run up Young's River as far as the lower end of the "cut-off," and 1 mile above the mouth of the Klaskuine. In the upper part of the river there is a least channel depth of about 2 feet at low water. The bed of the river contains a great many snags.

The channel through the "cut-off," although deep enough, is not over 50 feet wide and quite crooked. The upper end is boomed, and the old channel used by lumbermen to hold logs. The channel above the "cut-off" is very narrow and tortuous, and filled with snags, drift, and sunken logs.

A few hundred yards above the "cut-off" it shoals to 1 or 2 feet depth at low water. About one-half mile above the "cut-off" the depth was so little that I was unable to ascend farther in a small skiff, being less than half a foot at low water, and the stream in places not 8 feet wide, and much obstructed by snags and drift. The bottom consisted of soft rocky ledges.

Although the influence of the tides extends a short distance above to the pulp-mill, the channel appears to be unavailable for navigation at low water. Above the pulp-mill the river is but a small mountain stream, flowing through a thickly wooded district, without any considerable amount of agricultural land, and is used chiefly as a logging stream.

There is a pulp-mill located a short distance below the falls, to utilize their water-power and manufacture wood-pulp from the spruce and hemlock growing along the banks, to be boated on scows to Astoria, and thence shipped to San Francisco. I understand the capacity of this mill is to be 20 tons per day, though at the time of my visit it was not running, owing to the lack of water-power on account of the extremely dry summer. There are over 1,000,000 feet of saw-logs in the river above awaiting a freshet.

The small steam-boat *Rival*, drawing about 4½ feet, makes two trips per week from Astoria to just below the "cut-off," as well as up the Klaskuine to Kamm's Wharf.

THE KLASKUINE RIVER.

The tide extends up this river from its mouth in Young's River to a point a few hundred yards above Kamm's Wharf, a distance of nearly 2 miles.

A wagon bridge extends across the river just above the wharf. The Klaskuine to the wharf has a least depth in the channel of about 2 feet at low water, and is much obstructed by snags and sunken logs. It is from 100 to 200 feet in width. The land on either side is good, and is being rapidly brought under cultivation, and much hay and other produce is raised.

At Kamm's Wharf the county road from Astoria crosses, and is being completed to the Middle Nehalem Valley, a distance of about 25 miles, affording the only outlet to that region.

As before stated, the *Rival* makes two trips per week to Kamm's, to which point the steamer *Lurline* has also gone.

PROJECT OF IMPROVEMENT.

In the lower reaches of Young's River to the mouth of the Klaskuine but little improvement is needed or desired. I noted but two or three snags to be pulled out. From the junction of the Klaskuine to just below the "cut-off," a distance of 1 mile, a great improvement can be effected by removing the snags and sunken logs. Above the "cut-off," to the pulp-mill, a distance of less than a mile, I would not recommend any extensive improvement, as the stream is hardly worthy of it, and there is no very important interest to be served. About all that could be done for a reasonable expense would be to cut out the worst of the snags at low water.

PROJECT FOR THE IMPROVEMENT OF THE KLASKUINE.

To remove snags and sunken logs from its mouth to Kamm's Wharf, a distance of 1¼ miles.

ESTIMATE.

To remove snags from the channel in Young's River in the lower reaches below the Klaskuine	$75
To remove the snags and sunken logs in Young's River from the mouth of the Klaskuine to the lower end of the "cut-off"	700
To remove the snags in the Klaskuine River from its mouth to Kamm's	600
Contingencies, 20 per cent	275
Total	1,650

Very respectfully, your obedient servant,

J. S. POLHEMUS,
Assistant Engineer.

Capt. WILLARD YOUNG,
Corps of Engineers.

T T 10.

PRELIMINARY EXAMINATION OF NEHALEM BAY AND BAR, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, February 1, 1889.

GENERAL: I have the honor to report that the preliminary examination specified in section 13 of the river and harbor act of August 11, 1888, of Nehalem Bay and Bar, Oregon, has been made by Mr. J. S. Polhemus, assistant engineer, in compliance with the instructions contained in the letter of the Chief of Engineers, dated September 29, 1888.

In my opinion Nehalem Bay and Bar are worthy of improvement.

Mr. Polhemus reports:

The Nehalem River takes its rise in the Coast Range Mountains, about 20 miles from the Columbia River, and flows in a very circuitous route through a heavily timbered rugged country for over 100 miles, until it empties into the Pacific Ocean, about 40 miles south of the mouth of the Columbia River and 7 miles north of the entrance

to Tillamook Bay. It drains twenty-five townships, covered with some of the best timber in Oregon.

There are three principal scanty settlements on the river, known as the Upper, Middle, and Lower Nehalem valleys. My personal observations extended only over the Lower Nehalem settlement, including the bay and entrance.

A description of the Upper Nehalem can be obtained from the reports of Capt. Charles F. Powell of 1884 and 1886, as well as much other valuable information which it is unnecessary to repeat.

For 20 miles at least above the head of tide to the Middle Nehalem the river flows as a rapid stream over a rocky bottom between steep hills all covered with fine timber. It is not navigable, but I have been informed by old settlers that it offers good facilities for driving logs for 70 or 80 miles, being particularly free from drift and other obstructions.

The Nehalem flows through the largest body of timber on the coast of Oregon south of the Columbia River. The hills for many miles are covered with fine yellow fir and some cedar. On the bottoms and slopes near the bay spruce and hemlock predominate.

The Lower Nehalem extends from the mouth to the head of tide, about 13 miles. Here we find some narrow bottoms of good agricultural land and an area of tide lands suitable for grazing. About eighty settlers inhabit this part of the country, making a population of about 300 souls. Some dairying is carried on, and the butter hauled down the beach to Tillamook Bay for shipment.

About 400 head of cattle are raised and driven over the trail to Seaside for the Astoria market. M. J. Kinney owns a salmon cannery on the bay, and in the season of 1887 packed 7,500 cases, worth about $40,000. Last year the cannery was not operated, and the 25,000 salmon taken in the bay were hauled to the canneries at Tillamook.

Coal, a good quality of lignite, is found on Coal Creek, about 3 miles from the river, 10 or 12 miles from its mouth. It is probable that plenty of good lignite coal, such as is found at Coos Bay, will be found on the Nehalem when opportunities are offered for its shipment to market.

There is one small store situated on the Nehalem about 9 miles from its mouth, owned by Mr. Edward G. E. Wist, to whom I am indebted for much information. There are two post-offices on the lower river. The mail comes in once a week from Astoria over the trail on horseback via Seaside; also a mail via Tillamook Bay. No vessels run regularly, and all merchandise is brought into Tillamook Bay at a cost of $6 per ton from Astoria, then taken by boat to the mouth of Tillamook for $2 more, and finally hauled up the beach 7 or 8 miles to Nehalem at an additional cost of $5, making a total of $13 a ton freight on all goods transported to the bay.

On July 4, 1887, the steam scow *O. K.*, of Astoria, drawing 4½ feet, entered the bay with a cargo of lumber for Mr. Kinney's cannery, being the first vessel to cross the bar. Then the steamer *Walluski* made four trips from Astoria, bringing cannery supplies. The steamer *Tonquin*, drawing 6 feet, also made several trips. The sailing schooner *Queen of the Bay*, drawing 5 feet, was wrecked on the south spit while endeavoring to enter. The steamer *Polar Bear*, drawing 8½ feet, crossed in September 10, 1888, and departed next day for Astoria, since which time no vessel has been there, although 170 barrels of salt salmon are awaiting shipment.

An examination was made by the United States Coast Survey, October, 1868, giving soundings in the lower bay and inside the bar, also another by the same, in 1875, giving no soundings on the map.

Nehalem Bay at high water is about 2 miles long by 1⅛ miles wide at widest part, and is connected with the ocean by a narrow channel extending in a southerly direction about 3 miles, which varies in width from one-half to 1 mile at high tide. A low point of sand about 2½ miles in length lies immediately to the west of the bay and separates it from the ocean, and forms the north shore of the entrance. The south shore is also sandy, backed by long hills covered with spruce and hemlock.

Opposite the extremity of the north point a reef of basaltic rock extends into the channel, as indicated on the Coast Survey map. From the north sand point a submerged sand-spit extends southward for nearly a mile. The channel follows down on the inside of this spit and gradually turns and crosses the bar at present in a southwest direction. Any vessels that can now enter can ascend the bay and river a distance of 10 miles.

At the time of my examination, January 28, the bar was too rough to admit of sounding, although a good Columbia River fishing boat and crew were placed at my disposal. I observed the bar from shore for several hours at the last of the ebb and low water, and the channel crossed it as I have indicated on the Coast Survey chart.

Mr. August Schumacker, a resident of the bay, who piloted in the *Polar Bear*, and who has sounded on the bar several times, told me he found 5 feet least depth in bar channel at extreme low water, and Mr. M. J. Kinney, who has also sounded on the bar, reports about the same depth from his observations.

The average range of the tide is about 7½ feet, and spring tides 9 feet. The bar is of shifting sand, free from rocks. The channel shifts like on the other coast bars, and I am told sometimes in the winter and spring, during freshets in the river, has as great a depth as 16 or 17 feet at ordinary high tide.

The entrance inside opposite the rocks in the channel is choked to about its least width, being about 100 yards across, with a depth of 30 feet at low water. The current here, as well as for some distance below, has a velocity at the last of the ebb of about 6 miles per hour. Four men rowing a good boat could scarcely make any headway against it.

The northern part of the bay inside is largely occupied by extensive mud flats, bare at low tide, the channel hugging the south shore, and having a least depth of 10 feet at low water for 8 or 10 miles.

Settlers are continually coming to the Nehalem country, which is capable of supporting a much larger population if it enjoyed better transportation facilities. The country is now very inaccessible, especially in winter.

In my judgment the Nehalem is worthy of improvement if a careful survey should show this to be possible for a reasonable sum, for the reason that it would afford an outlet for one of the largest and most valuable forests of timber in the State of Oregon, and enable a section of country to support a greatly increased population. Without a survey one can only make a very approximate plan or estimate of the cost of such an improvement.

From the scanty data at hand the building of two jetties suggest themselves to me, located as I have indicated in pencil upon the map, each about 1,000 feet long. This would certainly form a more permanent bar channel and concentrate the outgoing ebb, and would cost, approximately, $100,000.

At present the Nehalem Bar admits of the crossing of small steam-vessels drawing about 8 feet, and if improved to admit of use by vessels drawing 10 feet could be used as an outlet for the lumber.

One of the largest and finest bodies of timber in Oregon lies along, and tributary to, the Nehalem River. The natural outlet for this is by way of the bay, as logs can easily be run down the river to the bay. If the bar shall be so improved that lumber-carrying vessels can enter the bay, saw-mills will be established without doubt, and a large trade will be built up. Besides this, large quantities of coal will then likely be shipped from the bay.

For these reasons, and because the cost will not be very great, I think that Nehalem Bay and Bar are worthy of improvement. The cost of such an improvement as is needed would be something like $250,000.

A careful survey of the bar and its approaches, as well as of the bay and the tidal portion of the river, will be necessary before a project can be prepared and a careful estimate of the cost of improving the bay and bar made.

The cost of such a survey would be about $1,500.

Very respectfully, your obedient servant,

W. YOUNG,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF NEHALEM BAY AND BAR, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, November 25, 1889.

GENERAL: In compliance with the instructions contained in your letter of April 1, 1889, I have the honor to transmit herewith a report of Mr. Gwynn A. Lyell, draughtsman, on the survey of Nehalem Bay and Bar, Oregon.

In the report submitted February 1, 1889, of the preliminary examination of Nehalem Bay and Bar, made by Mr. J. S. Polhemus, assist-

ant engineer, such points as could be ascertained by a personal examination and inquiry were mentioned. A subsequent examination of the bay and river, made by myself during the progress of the survey, confirmed me in the opinion that Nehalem Bay and Bar are worthy of improvement.

It is the concurrent testimony of men well qualified to judge that the largest and finest body of timber in Oregon lies along and adjacent to the Nehalem River. The natural route for this timber to reach a market is down the river and over the bar. Logs can easily be run down the river for a distance of 50 miles and more to tide water, where they can be sawed up, and, if the bar is improved, the lumber can be shipped by vessel to any port desired. To take the timber that is naturally tributary to the river by rail to the Columbia River, or to Tillamook Bay, or to the Willamette Valley, to be sawed and transported, would increase the actual cost of getting the lumber out several dollars for every thousand feet.

There are, I am told, whole townships of timber that will average at least 30,000 feet to the acre. This would be a yield of 691,200,000 feet for one township. If it be conceded that a saving of $1 per thousand feet in the actual cost of delivery of the lumber can be insured by improving the bay and bar, so as to let the timber take its natural channel to market, the saving on the timber of one township would amount to more than twice the estimated cost of the required improvement. But there are a number of townships of the finest timber directly tributary to the river. Besides this, there is a large body of excellent agricultural and grazing land around the bay susceptible of sustaining quite a large population.

The establishment of saw-mills will afford a local market for the products of the farms and the vessels employed in carrying the lumber to market will bring in needed supplies at less than one-third the present cost of transportation. All this will encourage immigration, which in its turn will tend to build up a thriving trade.

It is only by improving the bar that such results can be hoped for. To-day there is virtually no entrance to Nehalem Bay, at least none that is practicable for lumber-carrying vessels. The channel over the bar is constantly changing, being now in one position, and at another time it may be a mile away. Sometimes, as was the case when the survey was made by Mr. Lyell, there are two distinct channels.

The building of jetties will not only deepen the water over the bar, but will fix the position of the channel so that permanent land-marks may be established for the proper guidance of navigators.

At present Nehalem Bay has practically no commerce. The only boats that have entered the bay since the time of the preliminary examination in January last are the Government steamer *General Wright*, used in making the survey, and the steam schooner *Augusta*, which made two trips with cannery supplies. Both of these vessels draw about 7½ feet. A list of all previous entrances was given in the report of the preliminary examination.

The total tidal area of Nehalem Bay and River, computed from the land survey maps, is 3,556 acres, and of the bay proper, or the part shown on the accompanying map, 3,087 acres. The mean rise and fall of the tide is about 5.5 feet. A large part of the bay proper is occupied by mud flats, bare at low water. Parts of these flats are only just covered at high water; as the tide falls more and more ground is uncovered, until at low-water the area of the bay proper is reduced to about one-fourth what it is at high water. In the river above the bay

proper the low-water tidal area is practically the same as the high-water tidal area, the water being deep and the banks steep.

The distance from the mouth of the river to the head of the bay proper is about 5 miles, and to the head of tide about 13 miles.

The average tidal discharge is something like 20,000 cubic feet per second, or about half that at Yaquina Bay. The controlling depth inside the entrance is 8 feet, as shown on the accompanying map, where the width of the channel is 1,650 feet. Where the channel is narrower the depth is greater.

It is thought that high-tide jetties properly located will maintain a channel over the bar with a low-water depth of at least 8 feet.

PROJECT RECOMMENDED.

To build two high-tide stone jetties, located about as shown on the accompanying map, the jetties converging until the distance apart is about 500 feet, and then, if necessary, running out to sea parallel to each other to such a distance as will insure a low-water depth on the bar of at least 8 feet.

In order to secure the required depth at the earliest time practicable the jetties could at first be advantageously constructed of temporary pile-cribs filled with stone, similar to the work at the mouth of Coquille River, Oregon. This work could afterwards be made permanent by adding riprap.

ESTIMATED COST.

The situation is isolated and difficult to reach, and on this account the cost of labor and of materials other than piles and lumber will be somewhat higher than at other points along the coast where similar Government works are being carried on.

Stone of large dimensions it is thought will be difficult to obtain, but basaltic stone in small pieces suitable for the heart of the jetties is convenient and easily procured. It is believed that $4.50 per cubic yard will cover the entire cost of placing the stone in the jetties, including all items of expense in connection therewith.

The exact number of cubic yards of stone that will be required can not be told, as the existing conditions at and near the bar may be greatly changed by the time the work shall be undertaken.

The estimate for quantities is based upon the depths shown on the accompanying map and upon the supposition that the jetties shall be 6 feet above low water, the jetties being 10 feet wide on top and having a slope of 1 on 2 on the channel side and of 1 on 1½ on the outside.

In addition to the works needed to improve the bar some will be needed to improve the channel opposite Lazarus Island at the head of the bay. These will consist of snagging and dam construction, so as to confine the water to one channel. The snagging work will cost about $2,000. About 1,600 linear feet of dam would be needed, which would cost about $2.50 per foot, or altogether $4,000.

North jetty:		
Approximate length	feet..	3,400
Estimated amount of stone needed to construct	cubic yards..	12,937
Estimated cost, 12,937 cubic yards, at $4.50 per yard		$58,216.50
South jetty:		
Approximate length	feet..	3,300
Estimated amount of stone needed to construct	cubic yards..	47,420
Estimated cost, 47,420 cubic yards, at $4.50 per yard		$213,390.00

Estimated cost of both jetties	$271,606.50
Contingencies of all kinds 20 per cent	54,321.00
Total estimated cost of jetties	325,927.50
Lazarus Island Channel:	
For snagging work	2,000.00
For 1,600 linear feet of dam, at $2.50 per foot	4,000.00
Total estimated cost of all works needed	331,927.50

A tracing of the map of Nehalem Bay and Bar, made by Mr. Lyell from his survey notes, is sent in a separate package. The soundings on and outside of the bar are not as extended as they should be, owing to the prevalence of rough and foggy weather at the time the survey was made, and especially to the fact that the available funds were too limited to warrant the survey party's waiting for clear weather and a smooth sea.

Very respectfully, your obedient servant,

W. YOUNG,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. GWYNN A. LYELL.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, November 23, 1889.

CAPTAIN: I have the honor to submit the following report, with map of a preliminary survey of Nehalem River, Oregon, made in accordance with your instructions. The map is drawn on a scale of 1:5,000.

The Nehalem River rises in Columbia County and empties into the Pacific Ocean in latitude 45° 40′ north, longitude 123° 54′ west, approximately. Distance from Point Adams Light at mouth of the Columbia River, 37 miles, and from Tillamook Light 20 miles, approximately.

The entrance is flanked on the north by a long sand-spit, designated on the United States Coast Survey charts as Nehalem spit. The average height along the central portion of this spit is 10 to 15 feet above the high-water line.

On the right of the entrance is a low sand-flat, bare at low water, with an area of about 70 acres.

There are no buoys to mark the entrance. A second channel exists about three-fourths of a mile south of the present navigable channel. The Coast Survey charts of 1868 and 1875 show this channel open and that at the north entirely closed at low water. I am not informed as to the period in which the shifting of the channel occurs. The roughness of water prevented the running of lines out through the south channel.

The inner shore of the river opposite the entrance and up to Fishery Point, is composed of sand, gravel, and cobble-stones. Nearly opposite the lower end of the sand-spit a reef of rock juts out into the river for about 200 feet.

Indications of rock suitable for jetty construction were observed on the left bank of the river, half a mile or more above the entrance.

The left bank of the river from Kinney's cannery to the entrance is in places very steep, and covered with a dense growth of salmon brush, laurel, etc. The timber is mostly spruce of small growth.

TIDE-GAUGE.

A tide-gauge graduated to feet and tenths of a foot was set at northeast corner of Kinney's cannery wharf. The zero-mark of this gauge was set at average low tide as given in the United States Coast Survey tide-tables for Tillamook Bay, no predictions being given for Nehalem River, and is 13.85 feet below top of outer pile cap, against which the gauge was nailed.

The high and low waters were read on the gauge for eight or ten days consecutively, and compared with those given in the tide-tables for each day, and a correction for the zero obtained. The mean rise of tide for the period observed was 5.47 feet, as derived from a comparison with the Coast Survey tide-tables for the same period.

A base-line 1,000 feet long was measured on inside of Nehalem Spit. From this base were located four transit stations, and from these stations were located by intersecting sights. The high and low water lines were plotted by points located with a sextant. The seaward high-water line of Nehalem Spit, except around lower end, and the high-water line along left bank of river, were transferred from the Coast Survey chart of 1875.

For locating lines on which soundings were taken, 384 sextant locations were made, and 1,203 soundings were taken in the river and on the bar. They are expressed in feet, and reduced to mean lower low water; those on the bar were taken from the deck of the steamer *General H. G. Wright*, and for those taken in the river a small iron life-boat was used.

The lines along which the soundings were taken were located by two sextant observers, reading adjacent angles simultaneously.

The soundings were made with a small three-ply water laid cotton line graduated to feet, with a 6-pound lead sinker attached. The line was heaved usually every thirty seconds.

The position of the boat was located with the sextants every few minutes, and kept moving in straight lines at the rate of about 3 miles per hour.

The river was surveyed from the entrance to the islands above Kinney's cannery. The channel at the islands is obstructed by gravel-bars, formed by accumulated drift. Above the islands the banks of the river are low and the width contracted, affording deeper water than that below the islands.

The prevalence of strong northwest winds and foggy weather rendered it impossible for locating many lines for sounding on the bar. A heavy storm of wind and rain of four days' duration occurred during my stay in the Nehalem, and several days elapsed before the sea became calm enough for work on the bar or in the river.

Owing to the short time at my disposal, I could not wait for more favorable weather for the survey.

Very respectfully, your obedient servant,

GWYNN A. LYELL.

Capt. W. YOUNG,
Corps of Engineers.

T T 11.

PRELIMINARY EXAMINATION OF SIUSLAW RIVER AND BAR, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, December 22, 1888.

GENERAL: I have the honor to report that the preliminary examination specified in section 13 of the river and harbor act of August 11, 1888, of the Siuslaw River and Bar, Oregon, has been made by me in compliance with the instructions contained in the letter of the Chief of Engineers, dated September 29, 1888. In my opinion the Siuslaw River and Bar are worthy of improvement.

Attention is respectfully invited to the report of Capt. C. F. Powell, Corps of Engineers, page 2493, Annual Report Chief of Engineers, 1887, for a description of the river and bar, and for miscellaneous data.

The following extracts from letters received by me, in response to inquiries concerning Siuslaw River, are submitted as bearing directly upon the question whether or not the river and bar are worthy of improvement:

FROM LETTER OF MR. GEORGE A. MILLER, OF FLORENCE, OREGON.

The following list of vessels have entered the river, some of which have navigated the waters for 22 miles in the interior:

Alexander Duncan, three trips, 400 tons burden; *Whitelow*, one trip, 300 tons burden; *George Harley*, one trip, 100 tons burden; *Gussie Telfair*, three trips, 500 tons burden; *Arcata*, three trips, 500 tons burden; *Mary D. Humle*, one trip, 400 tons burden; *General Miles*, two trips, 300 tons burden; *Acme*, built here, but now in San Francisco, 80 tons burden; *Dolphine*, three trips, 150 tons burden; *Rosa Olsen*, five trips, 100 tons burden; *Mischief*, twenty-eight trips, 130 tons burden; *Amethyst*, one trip, 100 tons burden; tug *Fearless*, one trip; *Juno*, passenger boat; *Favorite*, passenger boat; *Mink*, passenger boat; *Emma Utter*, one trip, 600 tons burden; *Kate and Ann*, twelve

trips, 100 tons burden; *Two Sisters*, one trip, tonnage unknown; *Shultze*, one trip, tonnage unknown; *Augusta*, one trip, 200 tons burden.

Two other vessels, whose names are not ascertained at this time. These vessels have all been loaded coming in or going out, or both. The value of each cargo can not be ascertained, as there seems to have been no record kept; but each cargo of the *Mischief* and other vessels entering here recently will average $12,000 for each cargo.

We expect the Government to improve the entrance to the river by confining the channel by means of jetties or otherwise, to one place, so that it may wash deeper and be more easily followed by navigators. As the channel now is it drifts from one point to another over a distance of 1½ miles, and is often spread out or divided into several channels, none of which may be deep enough for such vessels as desire to enter.

There are thirty townships of very fine timber on the waters of this bay that must be taken to market over this bar. There are over one thousand people who live here now, and whose best source of supply and market are through this channel. Within a few years more this number will be doubled, and if commerce is encouraged by the Government improving the bar it is difficult to estimate the number that may find happy homes here. This bay supplies over forty townships, more or less, as it is at present, and will in course of time no doubt supply the larger part of the county of Lane. At Eugene City, 75 miles directly east, there is a company formed and ready to undertake the construction of a narrow-gauge railroad so soon as a favorable report can be had upon this bar, from Coburg, the present terminus of the Oregonian Railway, limited, through Eugene to deep water on Siuslaw Bay. Such a road would be of vast importance to all farmers along the east side of the Willamette Valley, and especially Lane County, as it could furnish them with a direct shipping route to the sea, which they do not now enjoy. The heavy freight of the Willamette Valley can not be carried over the three mountain ranges to San Francisco by means of railroads at such rates as will leave the producer a decent profit. It must seek water navigation at the nearest and most accessible point.

Sufficient surveys have been made to ascertain that very easy grades can be had from Eugene, and that the summit on the pass is not over 220 feet higher than Eugene City, and very probably a great deal less. The country abounds in iron ore and numerous deposits of stone-coal, all in an undeveloped state. These, with the vast forests of timber and water-power, will certainly make it a fine manufacturing country. * * *

FROM LETTER OF J. J. WINANT, MASTER OF STEAMER MISCHIEF.

I have been running to Siuslaw almost constantly during the past two years, and have passed in and out over the bar almost every month during the time. I have crossed at nearly low water in the spring of the year when the bar was smooth, finding not less than 9 feet. But the average soundings taken one month with another will not exceed 13 feet at high water. In the spring of the year, after the heavy rains of winter, the water is usually the deepest, and towards the latter part of the summer and fall, like most of the bars on the coast, there is less.

The freight taken in has consisted mostly of cannery supplies and merchandise, the amount reaching as high as 140 tons on some trips. The freight out has been mostly salmon—last season 16,000 cases, this season about 1,200; also hides and some lumber; approximate value about $200,000.

The names of other vessels visiting the place during the past two years are: Steam-schooners *Kate and Anna*, *Dolphin*, *Rosie Olsen*, and *Augusta*, steam-tugs *General Miles* and *Favorite*.

Steam-schooner *Acme* built there during the past season and sailed for San Francisco with lumber; also the three-masted schooner *Emma Utter*, about 400 tons, which was driven in on the south spit in a gale of wind in the night and beat over the spit into the river, sustaining but little damage. She was towed out by tug *Fearless* from Coos Bay.

Cargoes of salmon and merchandise have been insured by my vessel through to San Francisco via Yaquina at the rate of 1 per cent. Freight rates have been about $5 per ton to Yaquina, and from there to San Francisco about $2 per ton on canned salmon and about $5 per ton on merchandise. * * *

FROM JOINT LETTER OF MESSRS. A. G. HOVEY AND J. M. HODSON, OF EUGENE, OREGON.

* * * We know personally of an intention and an organization to build a line of railway from some point on the bay connecting with the systems of the Willamette Valley, and probably extending to eastern connections as soon as a positive assurance of the improvement of the bar can be had. There are many million feet of the finest lumber trees now standing in the western part of our county awaiting transportation facilities, and our people are very anxious to have direct communication with

ocean both for export of products and imports of needful articles, and the special benefits to be derived in the inducement of capital and immigration to come among us are indeed of such a large and important consideration, that every citizen of the county, so far as we know, is anxious for the necessary preliminary steps to be taken.

Our agricultural resources are yet in the infancy of development, not to speak of the lumber and fishing, which is each very large and almost untouched. * * *

In regard to the grades on the proposed railroad, we can say that following near the present county road you could not tell without an instrument where the divide actually is, and the grades will be less between Eugene and the head of tide than in many portions of the O. and C. in the Willamette Valley. Between the head of tide and the town of Florence there is some pretty heavy work, but nothing half so great as on the O. and P. between Corvallis and Yaquina. Our people will hail with pleasure anything looking to the opening up of this county, which can be greatly advanced by a very small appropriation for the improvement of the bar.

There is a strong desire on the part of the inhabitants of the Siuslaw region, and in fact of Lane County generally, that the entrance to the Siuslaw River should be improved. The principal reasons why an improvement should be undertaken are, it seems to me, that the bar is easily susceptible of improvement; that there is a fine harbor inside, and that an extensive lumbering trade will most probably be built up.

A chart of the river, made by the Coast Survey in 1883, from Florence to the sea, shows that the low-water channel depths are generally from 12 to 15 feet, and that the controlling depths are from 10 to 12 feet. The average width of the river at low water is shown to be about 900 feet and the average distance between 12-foot curves about 700. It is claimed that a 15-foot low-water depth can be carried to within a mile of the head of tide water, or for a distance of over 20 miles from the sea. The depth of water on the bar varies, but probably averages about 6 feet at low water. Jetties on either side of the entrance, suitably located, might be expected to increase this depth to about 10 to 12 feet. This, with an average tide of nearly 7 feet, would give a depth sufficient for the ordinary coasting vessels employed in the lumber trade. The jetties would, besides, serve to fix the position of the channel, which would be a great improvement over present conditions.

There is a large body of the very finest kind of timber on the headwaters of the river hundreds of square miles in extent. It is claimed that logs can be run down the river to tide water during the winter freshets from the very heart of this great timber belt. If so, saw-mills will doubtless be established along the lower river as soon as the bar is improved so that lumber-carrying vessels can cross in and out with safety.

If, besides this, a railroad shall be built from the Willamette Valley to deep water near the entrance, as is claimed will certainly be done if the bar is improved, the harbor will become one of considerable importance.

The prospective commerce is, I think, sufficiently great to warrant an improvement. The cost of such an improvement as is needed would be something like $300,000.

A careful survey of the bar and its approaches, as well as of the tidal portion of the river, will be necessary before a project can be prepared and a careful estimate of the cost of improving the river and bar made.

The cost would be about $1,500 for the survey of the entrance and lower part of the river and $1,000 for the survey of the upper part of the river.

Very respectfully, your obedient servant,

W. YOUNG,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF SIUSLAW RIVER AND BAR, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, November 25, 1889.

GENERAL: In compliance with the instructions contained in your letter of April 1, 1889, I have the honor to transmit herewith a report of Mr. Gwynn A. Lyell, draughtsman, on the survey of Siuslaw River and Bar, Oregon.

In my report of a preliminary examination of Siuslaw River and Bar, submitted December 22, 1888, I mentioned such points as I was enabled to ascertain by a personal examination and inquiry. These, in connection with the report of Mr. Lyell, are considered sufficient to show the propriety of improving Siuslaw River and Bar.

There are large bodies of the finest kind of timber along and tributary to the upper river which can not now be gotten to market at a reasonable cost. If the bar shall be so improved as to permit lumber-carrying vessels to enter and leave the river with safety, it will be possible to market this lumber at paying figures.

The timber could be gotten out with railroads, but only at a cost much in excess of that by boat. The bodies of timber that would naturally seek a market by going down the river and out over the bar are so extensive that the saving of even $1 per $1,000 feet in the cost of producing and delivering the lumber would amount to a sum several times greater than the total estimated cost of improving the entrance. The saving, however, would probably amount to several dollars per 1,000 feet, and besides other important benefits would result from the improvement.

A tracing of the map prepared by Mr. Lyell from his field-notes is sent herewith. The survey outside of the bar was not extended as far as was desired, owing to the unfavorable weather prevailing at the time the surveying party was in Siuslaw. It was not considered judicious to wait for good weather to complete the outside work, as there was much other survey work for the party and boat to do elsewhere, and as the funds available for this work were limited. It is intended that the survey on and outside of the bar shall be extended at the earliest time practicable in the spring, should funds be available for this work.

The total tidal area of Siuslaw River, computed from land survey maps, is 3,465 acres. The average rise and fall of the tide is about 5.5 feet. The distance from the mouth of the river to the head of the tide is about 22 miles. The average tidal discharge is something like 20,000 cubic feet per second, or about one-half that at Yaquina Bay.

The controlling depths inside the entrance, as shown by the accompanying maps, are 10 feet at low water where the width of the river is about 1,100 feet. Where the river is narrower the depths are greater. With the above discharge it is thought that a low-water depth of 10 feet on the bar can be maintained by the construction of proper jetties.

The shores on either side of the entrance are composed of sand, and the position of the entrance channel is liable to shift within the limits of about a mile. The channel could be made to take any position within the limits of this possible shifting.

The position suggested is at the southern limit and is taken because the necessary jetties in this case will be shorter and less expensive than in any other; and because it is said that the deepest water ever known on the bar—24 feet at high water—once obtained when the channel was in this position.

PROPOSED PROJECT.

It is proposed to build two high-tide stone jetties, located about as shown on the accompanying maps, converging until the distance between them is about 500 feet, and then, if necessary, running out to sea parallel to each other for a sufficient distance to open and maintain a channel over the bar with a depth at low water of at least 10 feet.

In order to secure the benefits of the improvement at the earliest time possible, it would be well to construct a part of the jetties, at least, of pile cribs filled with stone, similar in construction to the work at Coquille River, Oregon. Such work could afterwards be made permanent by the addition of riprap.

Spur groins should be used, if found necessary, to prevent undue scour along the face of the jetty; or, if found necessary, to give a proper direction or depth to the channel between the jetties.

ESTIMATED COST.

Stone is plentiful and easily obtained a few miles up the river. It is believed that it can be placed in the jetty for $4 per cubic yard, including all items of expense. The estimated cost of the jetties is based upon this figure.

The estimate for quantities is based upon the supposition that the top of the jetties shall be 6 feet above low water, the jetties being 10 feet wide on top and having a slope of 1 on 2 on the channel side, and of 1 on $1\frac{1}{2}$ on the outside.

North jetty:		
Approximate length	feet..	4,400
Estimated amount of stone needed to construct	cubic yards..	29,854
Estimated cost 29,854 cubic yards stone, at $4 per yard		$119,416
South jetty:		
Approximate length	feet..	3,800
Estimated amount of stone needed to construct	cubic yards..	28,519
Estimated cost 28,519 cubic yards stone, at $4 per yard		114,076
Estimated cost of both jetties		233,492
Contingencies of all kinds 20 per cent		46,698
Total estimated cost of both jetties		280,190

The commerce of Siuslaw River is at present very limited. The steam schooner *Mischief*, of 130 tons burden, makes regular trips from Yaquina Bay about twice a month, carrying in pretty full cargoes of general merchandise and cannery supplies and bringing out cargoes of canned salmon and dairy products. The salmon pack on the river this season is about 12,000 cases. The shipment of lumber from the river has not yet been commenced, owing to the unsatisfactory condition of the entrance.

A list of all vessels that have visited Siuslaw River was given in my annual report for the fiscal year ending June 30, 1889.

Very respectfully, your obedient servant,

W. YOUNG,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. GWYNN A. LYELL.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, November 23, 1889.

CAPTAIN: I have the honor to submit the following report, with map, of a preliminary survey of Siuslaw River, Oregon, made in July, 1889, in accordance with your instructions. The map is drawn to a scale of 1:5000.

The Siuslaw River rises east of the Coast Range Mountains, flows in a northwesterly direction, forming the boundary line between Douglass and Lane counties, emptying into the Pacific Ocean in latitute 44° north, longitude 124° west, approximately. There is no light-house in the vicinity. A buoy marks the entrance to the river.

The entrance is long and tortuous. The channel on entering runs in a northeasterly direction for some distance, then turns abruptly in a southerly direction into the river.

The northwest winds and swell from that direction tend to force the channel over against the south spit, so that the breakers on the north side and sand-spit on the south side have to be avoided.

There is a north and south channel, that at the north being the only one now open to navigation.

A sand-flat, bare at low water, with an area of about 120 acres, extends out almost into the channel and shifts with varying winds across the entrance. I was informed that in a period of about six years the channel shifts north and south in a distance of about three-fourths of a mile.

There are no prominent landmarks on either side of the entrance and out at sea no opening can be seen where the river empties into the ocean; and this renders navigation of the entrance difficult.

The bar is composed of sand, without indications of rock.

The river bluff on the right bank is of sand formation, 30 to 40 feet high, resting for the most part on a soft sandstone bed. For about a half mile up-stream from Cannery Hill the river bank is a steep sandstone bench, which is rapidly disintregating and falling into the river. Abreast of this bench for some distance the deepest water was found. Just north of Cannery Hill a rock-reef extends for some distance into the river, and is of a soft nature.

A slough makes in towards North Point signal-station and is believed to have been at one time the bed of the river. The stretch of sand between this slough and the ocean is covered with drift; no indications of rock are visible. Nearly opposite Florence, which is about 4 miles from the entrance, a high range of bare sand-dunes extends in a northerly direction between the river and the ocean, becoming gradually lower towards the entrance, where it forms the south spit.

TIDE GAUGE.

A tide-gauge, graduated to feet and tenths of a foot, was set at lower end of wharf in front of Hurd & Davenport's store in Florence. The zero mark of this gauge was set at low tide as given in the U. S. Coast Survey tide-tables for Siuslaw River. The high and low waters were read on the gauge for eight days consecutively and compared with those given in the tide-tables for each day, and a correction obtained for the zero.

	Feet.
Highest high water observed	7.4
Lowest low water observed	0.5
Mean rise of tide	5.4

BASE LINE.

A base-line 1,000 feet long was measured on west side of south spit; from this base were located nine transit stations, and from these were located the signal stations used in locating lines for sounding. For the location of the high and low water lines points were selected about 200 feet or less apart; these were located by sextant and the lines sketched in between them.

SOUNDINGS, ETC.

Two hundred and fifty-one sextant locations were made and thirteen hundred and thirty-four soundings were taken in the river and on the bar. They are expressed in feet and reduced to mean low water.

The soundings on the bar were taken from the deck of the Government steamer *General H. G. Wright;* for those in the river the steamer's small boat was used. For locating the lines along which the soundings were taken two sextants were used

and adjacent angles read simultaneously. The soundings were taken with a small three-ply water-laid cotton line, graduated to feet, with a six-pound lead sinker, heaved every thirty seconds. The position of the boat was located every few minutes and kept moving in straight lines at the rate of about 3 miles an hour.

FLORENCE—INDUSTRIES, ETC.

Florence, with a population of about one hundred, is situated on a sandy point on the right bank of the river, about 4 miles from the entrance; has a post-office, two large well-stocked stores, two hotels, a salmon cannery, and a tinsmith's shop. There is a good trade from up the river and vicinity.

All merchandise comes in by way of the river from San Francisco. It is carried by steamer to Yaquina City and from there it is brought down by the steam-schooner *Mischief*, this being about the only vessel now trading in the river. Mr. O. W. Hurd informed me that the following shipments were made from Florence and the up-river country for the year ending July 1, 1889, viz;

Salmon, 14,000 cases, valued at $6	$84,000
Live stock, valued at	100,000
Wool, fur, and hides, valued at	4,000
Chittim bark, valued at	4,000
Salt salmon, valued at	2,000
Total	194,000

A small steamer makes regular trips with mail and passengers to the head of tide, which is about 22 miles from the entrance. From the head of tide to Eugene the trip is made overland by wagon. A tri-weekly mail comes in by beach from Gardiner.

There is a ship-yard and salmon cannery at Rose Hill, nearly 2 miles above Florence, on the left bank of the river and nearly opposite North Fork, a small tributary.

Acme, just above the North Fork, is a small settlement, with a post-office, saw-mill, salmon cannery, and one or two stores.

The river valley is narrow, the greatest width being from a half to three-fourths of a mile; the bottom and tide lands are fertile, and have all been taken up by settlers.

Sandstone, suitable for jetty constructions, was observed, in fine ledges, at a distance of 4½ to 10 miles from the entrance.

The steamer *General H. G. Wright*, drawing about 7 feet, ascended the river to within 1½ miles of the head of tide and encountered no rocks or snags in the channel.

Ten feet at a minimum stage of tide can be carried from the entrance to Acme, which is about 7 miles distant; from there to the head of tide the river is narrow and deep, with depths varying from 10 to 20 feet.

I was informed that a surveying party started from Eugene the latter part of July to make a survey for a railroad from that place to Florence.

The people generally along the river are anxiously looking for Congress to appropriate money to improve the entrance.

Here, as at Nehalem, the wind blew from the northwest with considerable force, and rendered it impracticable at times to run lines for sounding even in the river.

The entrance was obscured for days at a time by dense fogs and the signal stations could not be seen.

Very respectfully, your obedient tervant,

GWYNN A. LYELL.

Capt. W. YOUNG,
Corps of Engineers, U. S. A.

T T 12.

PRELIMINARY EXAMINATION OF UMPQUA RIVER, OREGON, BETWEEN SCOTTSBURGH AND THE MOUTH.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, December 22, 1888.

GENERAL: I have the honor to report that the preliminary examination specified in section 13 of the river and harbor act of August 11, 1888, of the Umpqua River, between Scottsburgh and the mouth, has

been made by me, in compliance with the instructions contained in the letter of the Chief of Engineers dated September 29, 1888.

An examination of the Umpqua River was made in 1887 by Capt. C. F. Powell, Corps of Engineers, whose report will be found on page 2499, Annual Report of the Chief of Engineers, 1887, and to which attention is respectfully invited.

In my opinion the Umpqua River between Scottsburgh and the mouth is worthy of improvement.

Scottsburgh, the head of navigation on the Umpqua River, is a small town of less than one hundred inhabitants, situated about 26 miles from the mouth of the river, and at a short distance below the head of tide. Gardiner, the head of navigation for sea-going vessels, is a small town of about one thousand four hundred inhabitants, situated about 9 miles from the mouth of the river. These are the only towns on the river. Below Gardiner the river carries depths, at low water, of 13 feet and over clear to the sea. It is understood that no improvement of this part of the river is asked for. Between Gardiner and Scottsburgh the river carries depths of 9 feet and over, except for a short distance below Scottsburgh, and at Brandy, Echo Island, and Deane Creek bars, where, at low tide, the depths are reduced to 2 or 3 feet.

The obstructions just below Scottsburgh consist of ledges of solid sandstone rock. Brandy Bar, 6½ miles below Scottsburgh, is said to be composed of bowlders and gravel. Echo Island Bar, 1 mile farther down, of gravel and sand, and Deane Creek Bar, 10 miles below Scottsburgh, of sand and mud. They are all supposed to be underlaid by a solid bed of rock at no great depth.

Between Scottsburgh and Gardiner there are no roads nor trails, and but very few settlers. All communication between the two points, and between Gardiner and the mouth of the river, where the beach roads from Coos Bay and Siuslaw River terminate, is by water.

The banks of the river are, for most of the way, nothing but masses of stone, rising precipitously for hundreds of feet, so that road-building of any kind is impracticable, except at enormous expense.

The arable land along and tributary to the river is limited to a few hundred acres. There is considerable timber, and some tide lands, admirably adapted for dairy and stock ranches, but almost nothing else to furnish exports of any kind. The river between Scottsburgh and Gardiner is of importance only as a part of the principal route from the Willamette and Umpqua valleys to the coast regions around Coos Bay and the Lower Umpqua and Siuslaw rivers.

The products of that part of the Umpqua Valley stretching for 20 or 30 miles above Scottsburgh, and now amounting to from 200 to 300 tons annually find an outlet by way of the river. The tri-weekly mail from Drain, on the Oregon and California Railroad, to Gardiner and the Coos Bay and Siuslaw regions, is carried by stage to Scottsburgh. From there it proceeds by boat to Gardiner and the mouth of the river. The present mail boat is a small tug, drawing 4 feet, which carries passengers and a small amount of freight. If freight in any quantity is offered, it is caried on a small scow, which the boat tows. This mail boat is the only one running on the river between Scottsburgh and Gardiner. It is not probable that any more boats will be put on, nor that the one now running would make any more trips, if the improvements asked for were made.

The obstructions next below Scottsburgh do not extend down to the site of the old town of Scottsburgh, which is a mile below the present town. If the old town could be built up and made the head of naviga-

tion, the cost of the improvement asked for would be reduced about one-half. A wagon-road to the site of the old town could easily be put in repair so that the mail and passengers could be carried there by stage. The cost of improving the river from old Scottsburgh to Gardiner for a channel 4 feet deep at low water would be, I judge, about $25,000.

The cost of a channel 4 feet deep at low water between old Scottsburgh and the present town of Scottsburgh would be about the same.

A careful survey of the obstructions, with borings, will be necessary before a project can be prepared and a careful estimate of the cost of improving the river made, the cost of which would be about $500.

Very respectfully, your obedient servant,

W. YOUNG,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF UMPQUA RIVER, OREGON, BETWEEN SCOTTSBURGH AND THE MOUTH.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, January 16, 1890.

GENERAL: I have the honor to submit herewith preliminary report of Capt. W. Young, Corps of Engineers, on the improvement of the Umpqua River from Scottsburgh to its mouth, copy of report of Robert Warrack on the survey of the same, and tracings illustrating this survey. And I have to report as follows:

From the reports above cited and information gained during a recent visit to and trip upon the river, I am convinced that the only improvement now needed in this river is the removal of rock bowlders and ledges in the wharf basin at Scottsburgh and below this basin, to give a channel-way of 50 feet in width and 4 feet deep at low water. The cost of this work is estimated as follows:

Removal of 1,200 cubic yards of rock, at $6 per cubic yard	$7,200
Contingencies, superintendence, etc.	1,800
Total	9,000

At Brandy Bar, only a small fraction of a foot increased depth is needed to give the required 4-foot water-way at low water, and as a very slight delay would witness a sufficient rise in the tide to make up the deficiency, and as the solitary little steamer which plies the Umpqua always runs at high water, and as natural causes are at work building up islands which will probably give an increased depth of water without the expenditure of money, I think that it is not necessary to do anything to improve Brandy Bar.

The captain of the little Umpqua steamer told me that nothing was needed to be done to improve the river at Echo Island Bar, and Mr. Warrack's survey shows that nothing is needed at Deane Creek Bar. The boat which plies upon the river connects with beach wagons at the mouth of the Umpqua, which runs south to Coos Bay and north to the Siuslaw, necessarily at low water, and just as necessarily the boat runs at high water.

I have therefore to recommend an appropriation of $9,000 for removal

of rock from the Umpqua at Scottsburgh and below, and that no further improvement of this river be undertaken at present.

Very respectfully, your obedient servant,

T. W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. ROBERT WARRACK.

NEWPORT, OREGON, *November* 25, 1889.

SIR: I have the honor to submit the following report of the survey of the Umpqua River from Scottsburgh to its mouth, Oregon, made in accordance with your instructions of September 10, 1889:

The portions surveyed were—

First. The reefs immediately below the town of Scottsburgh.

Second. Brandy Bar, about 8 miles below Scottsburgh.

Third. Echo Island Bar, about 9 miles below Scottsburgh.

Fourth. Deane's Creek Bar, about 12 miles below Scottsburgh.

The rise of tide throughout the river varies from 5 to 7 feet.

The obstructions in the first section consist of a series of reefs of blue sandstone, extending diagonally across and down stream from right to left. There are also several bowlders lying in the course of the selected channel. In the wharf basin there are five bowlders which are dangerous to navigation at low water. Taking the wharf at Scottsburgh as a starting point, the first reef is reached at a distance of about 1,400 feet down-stream. This reef has already been drilled for blasting and the holes plugged; the depth of water on it is 2.5 feet. The next important obstruction occurs at 2,700 feet from starting point, and here there is a succession of reefs extending for a distance of 300 feet; the depth on these reefs varies from 1.5 to 3 feet. For a further distance of 700 feet the depth is about 3 feet, and the bottom rock covered with a thin layer of gravel. The bottom of the river is entirely of rock, although for about one-third of its width from the left bank it is overlaid with coarse gravel. Gravel is also deposited in the spaces between the reefs, evidently through the action of freshets in the river. These freshets occur every spring, and vary from 15 to 30 feet in height.

The banks on both sides are steep, that on the north side being rocky and heavily wooded, the south grassy, sloping about 1 in 2 to river, and covered with alder and willow brush.

BRANDY BAR.

The river at this point is divided into two channels by Brandy Bar Island. The north channel is closed by a gravel-bar across its upper end, on which the depth at low water is from 1.5 to 2 feet and at extreme low water it is said to be possible to walk along the bar almost dry-shod.

The channel used by steamers plying on the river is the south one, and in it the only obstruction is a gravelly bar 400 feet wide, opposite the center of the island, on which the depth is 3.7 feet. There is also a small area at the lower end of the island, in line of the channel, on which the depth is 3.5 feet, but there is ample channel width on each side of it.

It was noticed that the current during the first half of the flood and the last of the ebb ran much stronger through the south channel than the north, caused probably by the obstructions at the head of the north channel. These bars have not changed in recent years, so that the channel is well known.

The grassy islands to the south of the main island were at one time part of it, but were cut off in a freshet some years ago. The present indications are that they will soon be part of the main island again, and thus reduce the width of the south channel, though to a comparatively slight extent.

ECHO ISLAND BAR.

The river here is of such a width that it was impossible, with the instruments at hand and time available, to make a very thorough survey of the bar, which really extends down the river for a distance of about 2 miles, its west end being at the head of the island shown on the Deane Creek Bar survey.

The two lines of soundings may be taken as showing the width of the bar, and give for its least depth 2.5 feet in the line of the channel. Once across this bar, a good channel extends all the way to Deane's Creek.

What is now Echo Island Bar was formerly only the spit off the end of Echo Island, and at that time the slough round the island was a fair-sized stream, through which quite a large boat could pass. About fourteen years ago the snag shown at the west end of the bar grounded there, and since then a bar has gradually grown up on the down-stream side of it, which has now reached such a height that it is covered with grass and is practically an island dividing the river in two.

There is another crossing at the lower end of this island bar and at the head of the island shown in Deane's Creek survey, but the depth on it is so little better that by the time a boat reaches the upper crossing in a flood tide the depth on it is practically the same, and *vice versa* on the ebb.

The south channel is preferred by steam-boat men, as the north one is obstructed by sunken logs and snags.

The Gardiner Mill Company has obtained permission to put a pile-work boom half way across the river at the lower end of this bar and for some distance along the bar island. It is probable that the lower crossing will be closed up, so that either a new crossing must open somewhere in the bar or the present Echo Island bar will scour out. It is the opinion of steam-boat men on the river that, as it is altogether a sandy bar, it is not at all improbable it may scour out during some freshet accompanied by low water.

DEANE'S CREEK BAR.

This bar is practically an island and is now to the south of the channel. It is grass-grown and is in no way an obstruction. There is a small middle ground with 3.5 feet of water on it to the north of its west end, but there is abundant channel room on each side, with ample depth of water.

The steamers on the river go almost always with the tides, as they have to connect with the Coos Bay stage on the beach, so that none of the last three obstructions interfere very greatly with navigation.

At Scottsburgh it is occasionally necessary, when waiting for the stage, to drop the steamer below the reefs and convey the passengers to her in small boats. The steamers runningon the river are the *Juno*, a screw-propeller boat drawing about 4½ feet, and the *Restless*, a stern-wheel boat drawing 20 inches.

COMMERCIAL STATISTICS.

Wheat shipped down annually	tons..	325
Wool shipped down annually	pounds..	70,000
Hops shipped down annually	do....	20,000
Leather shipped down annually	do....	12,000
Deer hides shipped down annually	do....	5,000
Logs towed down annually	feet, B. M..	5,000,000
Raw hides shipped up annually, about	pounds..	40,000
General merchandise shipped up annually, about	tons..	500

Passengers carried annually, 1,500 to 1,800 in number.

The steamer makes three trips a week, to connect with mail and stage at Scottsburgh, and between the two boats about 180 trips are annually made.

PLANS.

Plans showing the aforementioned obstructions are submitted herewith.

Very respectfully, your obedient servant,

ROBERT WARRACK.

Capt. WILLARD YOUNG,
Corps of Engineers.

APPENDIX U U.

IMPROVEMENT OF THE MOUTH OF THE COLUMBIA RIVER, OREGON AND WASHINGTON, AND CONSTRUCTION OF CASCADES CANAL, COLUMBIA RIVER; IMPROVEMENT OF COLUMBIA AND WILLAMETTE RIVERS BELOW PORTLAND, OREGON; OF UPPER WILLAMETTE RIVER, OREGON; OF COWLITZ RIVER, WASHINGTON; WATER-GAUGES ON COLUMBIA RIVER.

REPORT OF MAJOR THOMAS H. HANDBURY, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

IMPROVEMENTS.

1. Mouth of the Columbia River, Oregon and Washington.
2. Construction of canal at the Cascades, Columbia River, Oregon.
3. Columbia and Lower Willamette rivers below Portland, Oregon.
4. Willamette River above Portland, Oregon.
5. Cowlitz River, Washington.
6. Gauging waters of the Columbia River, Oregon.

EXAMINATION AND SURVEY.

7. Upper Columbia River, Washington, between Wallula and British line.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, July 8, 1890.

SIR: I have the honor to submit herewith annual report for the fiscal year ending June 30, 1890, upon the works of improvement in my charge.

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

U U 1.

IMPROVEMENT OF MOUTH OF THE COLUMBIA RIVER, OREGON AND WASHINGTON.

The project under which this work is being carried on was adopted in 1884. It contemplates providing a channel across the Columbia

River Bar, having a depth of 30 feet at mean low tide. This is to be effected by concentrating the water flowing over the bar and increasing the resultant currents to such a degree as to procure the desired depth. Any work for accomplishing this end must be more or less tentative in its character. The work which is now in progress is the building of a low-tide jetty, starting from Fort Stevens, on the South Cape, and extending in a westerly direction, with a slight curve to the south, out across Clatsop Spit, for a distance of 4½ miles, more or less, as circumstances may require, to a point about 3 miles south of Cape Hancock (Disappointment). The jetty is constructed of stone, resting upon a mattress foundation about 40 feet wide and from 2½ to 5 feet thick. The stone extends to the level of mean lower low water. The material thus far has been placed in position from a jetty tramway supported upon piles driven along the line of the jetty, and about 24 feet above the level of low tide. The tramway is a double track, 3 foot-gauge railroad, the tracks being 13 feet between centers. The material is landed at the wharf and transported to place over these tracks, which are built in advance of the main work.

Before the commencement of this work the channel or channels over this bar were very capricious in location and variable in depth. The depths were usually from 19 to 21 feet and the channels varied in number from one to three, and in location through nearly 180° from Cape Disappointment around to Point Adams.

The effect of the jetty already constructed is now very marked in the building up of Clatsop Spit and in concentrating the ebb waters upon the middle sands of the bar. These have been entirely removed, and where they once existed there is now from 18 to 25 feet of water.

The first appropriation for this work was made in the river and harbor act approved July 5, 1884.

The amount appropriated for the present project to the end of the present fiscal year is $862,500. The amount expended, including outstanding liabilities, is $841,049, leaving a balance of $21,451 applicable to the further prosecution of the work.

At the end of last fiscal year the jetty tramway was at Station 108 + 16, and the mattress work was at Station 99 + 04. At the end of this year the tramway is at Station 198 + 24 with the mattress work at 194 + 08, being an advance of about 1.7 miles. Station 25 + 80 being the commencement, the jetty may be regarded as being under construction for a distance of 3.26 miles. Rock has been dumped to a height of mean low water over an average of about 3 miles of this distance. The depth of water where the piles for the tramway have been driven has varied from 9 to 14 feet.

If it is found necessary to extend the jetty to the limit of 4½ miles contemplated by the project, the tramway must yet be extended 1 mile and 1,236 feet. This distance will be covered before the end of the present season, if the funds necessary for the purpose are available when needed.

Pile-driving at the end of the jetty tramway was discontinued November 18, and resumed again April 1. This is the season of violent storms in this locality, when work of this character can not be carried on without great expense and great danger to life and property. The day before the pile-driver was brought in from the end of the tramway last fall, a wind velocity of 88 miles an hour was registered at Fort Canby.

Rock was received under the existing contract with Perry Hinkle until December 25. The last barge load was discharged at Fort Stevens on December 30. About this date the weather became very inclement

and there was every indication that the Columbia River would shortly be obstructed by ice and closed to navigation entirely above the mouth of the Willamette. The delivery of rock was resumed March 15.

Advantage was taken of this suspension to put the tow-boat *Cascades* and four of the older barges of the fleet in repairs. The cylinder timbers of the tow-boat that had become old and decayed were replaced by a full set of new ones. The wheel, which was too near the stern bulkhead, was set aft eighteen inches with view to giving the boat greater backing power and otherwise improving her capabilities when maneuvering backward. The results from this change are very satisfactory. The decks of the four barges were entirely removed. Some minor repairs were made to the other barges.

During the winter and spring a large amount of work was done in the shops at Fort Stevens. Fourteen dump-cars of the new self-righting pattern were constructed for the transportation of rock. Four flat cars for brush were also made. All the old cars were overhauled and put in thorough working order. The experience of the year has shown the self-righting rock dump-cars to be admirably adapted to the service required of them. A train of 20 of these cars, loaded with from 5 to 8 tons of rock each, can be dumped by two men in five minutes. A considerable saving in the cost of dumping has resulted from the adoption of this car.

It was apparent at the end of last season that the pile-driver, which has been in use since the commencement of this work, was becoming very shaky, and in all probability would not last another season through. To have a breakdown of this machine in the midst of the good working season would put a stop to progress and entail an expensive and vexatious delay until a new one could be provided. To insure against anything of this kind advantage was taken of the winter and spring months to construct on the work a new pile-driver. It differs in no essential from the old one, excepting in the bearing trucks and the rollers on which it revolves.

As the machine is somewhat unique in design, an outline drawing is herewith submitted. It will be observed that it rests on a large platform which is supported upon the two railroad tracks by four double trucks, one at each corner, each having eight wheels, or on thirty-two wheels in all. By means of suitably arranged machinery, the pile-driver is turned on this platform about a central pivot, the weight being taken up by a number of small rollers arranged to run between two tracks made of railroad iron bent into circles. At one end of the pile-driver frame is the gin with its hammer, at the other the boiler that furnishes the steam to the hoisting-engine and jet-pump. This engine occupies the center of the frame. The piles are driven by means of two hydraulic jets, one on each side of the lower end of the pile. The water for this purpose is furnished by a pump which hangs in a frame over the side of the pile-driver, always within suction limit of the surface of the water. The length of the pile-driver frame is sufficient to permit of bents being driven 20 feet apart. These, however, are only 16 feet apart. The pile-driver is accompanied by what is called the pile-driver tender car. This is a large car which extends over both tracks. Every morning it is run out with the supply of material to be used at the head of the jetty during the day, and in the afternoon is returned to the material depot and loaded.

Accompanying this report are drawings which show the construction of the jetty tramway and also the methods of making and sinking the mattresses.

Telephone communication has been established between the end of the jetty tramway, the office, and the wharf. This has been found a great convenience in sending supplies to the front and in landing the trains.

During the year 120,354 tons of rock were received from Perry Hinkle under his contract of January 8, 1889. Under date of May 8, 1890, Mr. Hinkle was notified that 30,000 tons additional would be taken on completion of the delivery of 150,000 tons.

The total amount of rock that has been received at Fort Stevens from all sources, from the commencement of the work to the end of the present fiscal year, is 212,691 tons. Under his contract of March 9, 1889, Charles P. Church has delivered 3,811 cords of brush and 6,938 poles. These amounts closed this contract. Proposals were invited by public notice of sixteen days, by posters, for the delivery of 5,000 cords of fascines and 9,000 poles at Fort Stevens, with the option on the part of the Government of doubling those amounts at the same prices if desirable. Mr. Church was again the lowest bidder in $2.84 per cord of 128 feet for the fascines, and $23\frac{3}{4}$ cents each for the poles. Contract was entered into with him March 24, 1890. Under his contract he has delivered 2,873 cords of fascines and 5,574 poles. There has been delivered on the works during the year 7,998 cords of fascines and 15,614 poles.

There has been purchased during the year 133,310 linear feet of piling, at a cost of 8 cents per foot, delivered. The piles are from 55 to 65 feet in length, with occasional longer length, for which $8\frac{1}{2}$ cents per foot is paid. These were all used in the extension of the jetty tramway.

The lumber purchased amounts to 1,191,727 feet. For that delivered last summer and fall $10.25 per thousand, at Fort Stevens, was paid. For what has been used since resuming operations this spring the cost has been $10 per thousand.

One hundred and five tons of railroad iron were purchased and delivered at Astoria, at a cost of $51.34 per ton of 2,000 pounds. This will be sufficient to complete the railroad tracks as far as is contemplated by the project.

Accompanying this report is the usual map, showing the extent of the jetty constructed and the low-water lines of the last two years. An examination of these will give some idea of the extent of the change that has taken place. In the spring of 1889, when the wharf was last extended, there was from 20 to 25 feet of water all along its head. It was thought at that time that the sand-spit would not seriously encroach upon this water. Now low water finds the inner side of the end of the wharf-head bare. It is quite probable that a farther extension of the wharf may be necessary during the coming year. In the vicinity of the jetty large accretions have taken place, both on the north and the south sides. The indications are that the beach will soon be moved outward on a line running southeast from a point near the projected end of the jetty. Most of the area included in the triangle, bounded by this line, the jetty and the high-water line at Point Adams, is now bare at low water. There are between 3 and 4 square miles in this tract. The sand is also building up on the north side of the jetty. During the prevalence of the high water of the Willamette River last February, large quantities of heavy drift were brought down to the sea. We were troubled a great deal with heavy trees and logs coming against the tramway at this time. Some piles were broken and knocked out of place and the capping pieces loosened on several bents. In anticipation of something of this kind, rock was piled in nearly to high water

along the inshore end of the jetty, during last fall and winter. The prevailing winds at that time caused the logs and large trees to draw in toward this portion of the jetty, and gave great trouble. The effect of piling up the rock here was good, and undoubtedly saved the tramway from much damage.

With the view to ascertaining definitely the effect that the jetty was having upon the bar at the mouth of the river in September and October last, a thorough hydrographic survey was made. This extends from Tansy Point out over the bar to the deep water. The map made from this survey has been published and copies distributed to pilots and ship captains visiting these waters. A comparison of this, with the survey of 1885, made about the time the jetty was commenced, shows that great changes have taken place on the bar in the interval between the two surveys. The most marked change in the interests of navigation is the entire disappearance of what was then known as the "Middle Sands." The same channel depth over the bar that was then available for 1½ miles, is shown by the present map to be available for a width of 5 miles. This depth is shown to be between 18 and 22 feet at a mean of lower low waters. A good 22-foot channel was then available. A few soundings recently taken on the bar shows that there is now a straight out and in channel with 25 feet at low water. In 1885 the distance between the 30-foot curves on the outer and inner sides of the bar was 1½ miles. The distance is now only one-half mile, as shown by the recent soundings.

In my annual report of last year it was stated that the funds at that time available would be substantially exhausted, so far as actual progress on the jetty was concerned, at the end of the working season, and that it would be in the interest of economy if additional funds could be provided so that work could be resumed and pushed early in the spring. In response to a resolution of the House of Representatives requesting information relative to the necessity for early resumption and continuation of the improvement of the mouth of the Columbia River, the Secretary of War, under date of January 9, 1890, transmitted a brief report showing the amount of work done from June 30 to November 30, 1889, and farther explaining the necessity for an early appropriation. Resulting from this, by a joint resolution approved February 22, 1890, the sum of $75,000 was made available. This timely addition has been of great benefit to this work. It has permitted the extension of the jetty tramway to be resumed April 1, with an addition to that structure of 3,504 feet to June 30. This could not have been built without this exceptional appropriation. It has put the work in such a condition that the tramway can be completed this year provided the regular appropriation for river and harbor works is not delayed beyond the usual time. It has also prevented the necessity for discharging our well-organized force and laying up our large and expensive plant.

During last summer and fall the work was visited by several distinguished Senators and members of the House of Representatives. Some of these gentlemen have done the Engineer Corps the honor to publicly express their admiration of the methods in practice there, and the results that have been attained, all of which is very gratifying to those who have been connected with the work.

For additional details pertaining to this work during the year, attention is invited to the report of Assistant G. B. Hegardt, herewith transmitted, who has been in local charge, and has discharged the duties of his position with commendable zeal and ability.

ESTIMATE FOR THE YEAR ENDING JUNE 30, 1892.

It is estimated that $500,000 can be profitably expended upon this work in the fiscal year ending June 30, 1892.

The estimate for the construction of this work submitted by the Board of Engineers, whose general project for the improvement was adopted in 1884, was $3,710,000. Of this amount there has been appropriated to June 30, 1890, $862,500. There was a balance on hand at that date of $21,451.86, exclusive of outstanding liabilities. This balance will be barely sufficient for the needs of the work until the end of the present July.

It is imperatively necessary, if this work is not to be suspended, that a portion of the funds that are to be provided for its prosecution during the year ending June 30, 1891, be made available at an early day.

The progress made and the results obtained with the funds already appropriated are beyond the most sanguine expectations. A revision of the estimate for completing the work based on the experience gained in what has already been accomplished, will bring the total cost for obtaining a channel from 28 to 30 feet deep across the bar far within the original estimate; provided always that funds are available for pushing the work. It seems to me now that with a continuation of favorable conditions as regards funds and the forces of nature striving as they have been doing to build up the sand on both sides of the jetty, the work can be finished with the additional appropriation of $1,000,000. Although our work has passed through some very severe storms without material injury, it may happen at any time that such a change may take place in the forces at work upon Clatsop Spit as to bring about an unfavorable set of conditions. In that event, to accomplish our object a larger amount of money will be necessary. No man can predict what the Pacific Ocean and the Columbia River are going to do next with the sands that they have brought together at their junction.

APPROPRIATIONS.

July 5, 1884	$100,000
August 5, 1886	187,500
August 11, 1888	500,000
Total	787,500

Money statement.

July 1, 1889, amount available		$173,247.08
Amount appropriated by act of February 22, 1890		75,000.00
		248,247.08
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$197,085.00	
July 1, 1890, outstanding liabilities	1,854.93	
July 1, 1890, amount covered by uncompleted contracts made during the fiscal year ending June 30, 1890	27,855.29	
		226,795.22
July 1, 1890, balance available		21,451.86
Amount appropriated by act of September 19, 1890		475,000.00
Amount available for fiscal year ending June 30, 1891		496,451.86
Amount (estimated) required for completion of existing project		525,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		500,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Abstract of sealed proposals for poles and brush fascines for use in improving mouth of Columbia River, Oregon.

[Opened at 12 m., March 10, 1890, by Maj. Thos. H. Handsbury, Corps of Engineers, U. S. Army, at Portland, Oregon, after 16 days' public notice.]

No.	Name and address of bidder.	9,000 poles.		5,000 cords fascines.		Aggregate amount of proposal.
		Per pole.	Amount.	Per cord.	Amount.	
		Cents.				
1	Chas. P. Church, Portland, Oregon	23¾	$2,137.50	$2.84	$14,200.00	$16,337.50
2	Warren & Wright, Astoria, Oregon	30	2,700.00	3.18	15,900.00	18,600.00
3	John Shepherd, Portland, Oregon	22¾	2,047.50	2.49	12,450.00	14,497.50
4	Thomas P. Randall, Oregon City, Oregon	27	2,430.00	2.98	14,900.00	17,330.00

Bid No. 3—Conditional, viz: "Provided the Government does the towing from the channel of the Columbia River."

The balance of appropriation available, at this date, after deducting all outstanding liabilities, is $75,000.

NOTE.—The cost of towing from "Channel of the Columbia River" is added to prices of bid 3; it is in excess of bid 1, which is the lowest.

REPORT OF MR. G. B. HEGARDT, ASSISTANT ENGINEER.

FORT STEVENS, OREGON, *July* 1, 1890.

MAJOR: I have the honor to submit herewith the following report of operations on the improvement of the mouth of Columbia River, Oregon and Washington, for the fiscal year ending June 30, 1890.

JETTY TRAMWAY.

During the fiscal year the tramway has been extended 9,008 feet, from station 108+16 to station 198+24, and the bracing of it brought from station 96+00 to station 192+80, a distance of 9,680 feet.

Pile-driving was suspended on November 18, and again resumed on April 1.

It has been intended to continue the driving up to December 1, but the roughness of the weather made it necessary to take in the driver at an earlier date.

The pile-driving has continued without interruption during the working months, with the exception of twelve days in the first part of June, when a change of drivers and repairs to machinery made a suspension necessary, and occasionally a day on account of rough weather.

Piles 60 feet long have been used exclusively, except at the commencement and close of a season's work, and during the month of June, when piles 65 and 70 feet long were used.

The depth of water at the end of the tramway during the month of June has been about 20 feet, which leaves a 65-foot pile about 18 feet in the sand.

The mean depth of water, in which the piles were driven previous to June, was about 10 feet, varying from 5 to 16 feet below mean lower low water.

In August the end of the tramway was nearing "Tillamook Chute" as it was shown on the chart of the survey of 1885, and at the end of September the tramway had been extended across this "chute" and has reached the 12-foot contour on the opposite side, as shown on the same chart.

"Tillamook Chute" had in 1885 24 feet water, but when crossed by the tramway, the greatest depth of water found was 9 feet below mean lower low water.

Four cross-over tracks were put in on the tramway during the year at stations 97, 117, 136, and 156, to facilitate the handling of trains.

During the fall and winter months some very severe weather was experienced, the velocity of the wind being at times from 50 to 60 miles per hour. The most violent storms occurred on September 28 and November 27, when the velocity of the wind registered at Fort Canby 76 and 88 miles per hour.

All these heavy wind-storms were followed by very high tides, but the tramway was in no way damaged by either.

The greatest danger to the tramway is from drift and logs coming down with freshets in the Columbia and Willamette rivers.

During the flood in the Willamette, in the early part of February, a large amount of drift came down at different times, and floated on to the jetty and lodged among the piles in the tramway. Five piles were broken off and washed away, and a number of others knocked from under the caps.

Fortunately there was comparatively no sea on at the time when the largest amount of drift came down, or the damage would have been more serious.

Ninety piles had to be pulled back in place and rebolted to the caps, and scarcely a pile could be found that had not been chafed by the drift and logs.

To replace the broken off piles, the pile-driver had to be fitted up and run out on tramway. This was done on the 19th of February, and on the 25th the repairs were completed and the pile-driver hauled in and laid up.

Contrary to expectations, we were successful in driving the new piles through the rock and managed to get them about 16 feet in the sand.

The June rise in the Columbia did not carry much drift, and only one pile was broken off and a number knocked out of place.

The work being carried on with full force at this time, a closer watch could be kept and the logs taken out of the tramway before any damage could be done.

A large number of logs and trees were cut up as they floated on to the beach, so that with the next high water they should not float off again and go on to the jetty.

The large amount of rock dumped in front of the oldest part of the tramway, station 25+80 to station 40+00, no doubt saved this portion of it, as the greater amount and the largest pieces of drift are washed against this stretch of the tramway.

At the commencement of pile-driving this spring soundings were taken ahead of the tramway for a distance of about 5,000 feet, and a mean depth of about 13 feet below mean lower low water was found.

The strong run-outs caused by freshets in the river have, however, scoured the sand away to a depth of 16 to 20 feet.

In February, during suspension of active operation, the tracks for the entire length of the tramway were straightened, the rails only being taken up.

Two men have been constantly employed during the working season to keep the tramway tracks in good repair.

The only accident which has happened to the rock-trains occurred in July, on the tramway, when the safety-pins dropped out, allowing the car to dump itself while running, the rock breaking one pile and the cap. The pile-driver had to be run back to put in the new pile.

Experiments have been made during the year to stop the corrosion of the rails by coating them with crude oil and spirits of paraffine, mixed in different proportions, and applied hot to the hot rail, but without success.

No difference could be noticed in the condition of the coated rails and those not coated after the rails had been in the track for a couple of months.

One hundred and thirty-three thousand three hundred and ten feet of piling were furnished for the tramway by G. W. Bloom, contractor.

Wire has been strung along the track of the tramway and telephone connection made with the pile-driver, the office, and the wharf.

The great distance to the front made it necessary to have some more convenient communication with the pile-driver than the use of a steam-whistle and sending a locomotive to the front to find out what was wanted.

JETTY.

The jetty proper is now under construction for a distance of a little over 3¼ miles, station 25+80 being considered as the commencement or root of the jetty proper.

The mattress-work of the jetty has been advanced from station 99+04 to station 194+08, a distance of 9,504 feet.

No change in the size or general construction of the mats has been made during the year.

The rock in the jetty is now up to mean low lower water as far out as to station 170+00, or about 2¾ miles. Beyond station 170+00 and as far as the mattress-work is in, or station 194+08, the rock is about 9 feet on the mats.

One hundred and twenty thousand three hundred and fifty-three and five-tenths tons of rock were received during the year. Of this amount all but 3,500 tons, which were dumped in front of the shore-protection spur, was placed in the jetty.

At and about station 65+00 the rock showed signs of sinking and a large amount of rock had to be dumped at this place.

The crossover tracks at this station, 65+00, were taken up to allow the rock to be dumped from between the tracks.

At no other point on the jetty has it been necessary to dump more rock after it has since been brought up to level of mean lower low water.

Nine thousand six hundred and eighteen tons of rock were dumped between stations 25+80 and 70+00, and the greater portion of it between stations 25+80 and 45+00.

From the root of the jetty, station 25+80, to sttaion 45+00, the oldest part of the tramway, the rock was dumped to a level of about 4 feet above mean lower low water, for the purpose of protecting the piles in the tramway and prevent them from being broken off and knocked out of place by logs which drift against the jetty at this point.

Seven thousand nine hundred and ninety-seven and forty-one one-hundredths cords of fascines and 15,614 poles were used during the year for the mattress-work of the jetty.

The fascines and poles were furnished by Charles P. Church, under contracts of March 9, 1889, and March 24, 1890.

The rock was delivered by Perry Hinkle, under contract dated January 8, 1889.

Three hundred and two and seven-tenths tons of small rock for use in sinking mats was purchased from Peter Cain, St. Helens, Oregon, at 90 cents per ton.

The last mats of last season were sunk on December 13, and the last rock discharged December 31.

To further protect the end of the tramway from the winter storms, mats were also sunk on the south side from station 162+72 to station 161+58, a distance of 120 feet.

The rock at the end of the jetty in December was about 6 feet thick on the mats and gradually sloped up until station 145+00 was reached, where it was up to mean lower low water.

No more rock was dumped toward the end of the jetty, so as not to obstruct the flow of water and cause the spits to be cut away, and also so as to prevent a heavy scouring of the sand at the end of the tramway.

The scouring away of the sand from around the piles between the time of driving the piles and the sinking of the mats has averaged about 4 feet, being in some instances as much as 7 feet, depending greatly on the progress of the mattress-work.

When the mats are kept close up with the driver the scouring is generally only a few feet, but as the mattress-work falls behind the scouring increases.

The depth of water in which the mats have been sunk varies all the way from 9 to 20 feet.

The sand has continued to back up against both sides of the jetty and the spits have increased in size, showing considerable more bare surface at low water.

The racing of the waves along the jetty has been about stopped by the forming of these spits, as is shown both by observing the action of the waves and the fact that the spits are steadily moving closer on to the jetty.

Owing to freshets in the Columbia River, the receipt of rock during the month of May was small as compared with the general average, being only about 9,000 tons.

The towing of the rock-barges between the quarry and Fort Stevens has been done, as last year, by the Government and with as satisfactory results.

Accompanying this report will be found a drawing showing in detail the manner in which the "inside" and outside mats are made and sunk.

SHORE TRESTLE.

The only work necessary to be done to the shore-trestle has been the placing of high switch-stands at all crossings with the main tracks, and the leveling, blocking up, and straightening of the tracks. This latter was done during the month of February.

WHARF.

The west track of the wharf and approaches was widened from 8 to 9 feet centers. To do this, re-enforcing stringers were placed under the outer rail for a distance of 700 feet.

Double track, with 9 feet centers, now runs continuous from the wharf to the root of the jetty, after which the double track has 13-foot centers all the way out to the end of the tramway.

The beach at the wharf has been building out very rapidly, and the old wharf, with one derrick on it and used during the first part of the fiscal year, has been rendered useless on this account.

The closeness of the beach to the wharf causes quite a swell at high water, and specially so in the fall and winter months, making it at times difficult to discharge rock-barges.

Piles were driven at the wharf and a house built for a self-registering tide-gauge to be used during surveys of the bar.

Owing to the filling of the sand at the wharf this gauge was never used.

GRIDIRONS, SPURS, AND SIDE TRACKS.

The gridiron at the "Y" was extended 90 feet, to accommodate the larger number of piles necessary to keep on hand for the tramway construction.

The track between the gridirons at the "Y" was also extended 90 feet.

For storing the small rock used in sinking mats a small gridiron 20 by 80 feet has lately been built near one of the tracks at the wharf.

For building the new pile-driver the old pile-driver tracks have to be extended 100 feet and working platforms put in on each side of these tracks.

The platform on the east side of the tracks is 40 by 80 feet, and that on the west side 20 by 60 feet.

The track of the shore-protection spur, in front of the shore-trestle and the buildings of the work, was extended 748 feet. Mats were placed for a distance of 1,010 feet in front thereof and about 3,500 tons of rock dumped thereon.

All along this spur the rock is dumped up to about 12 feet above mean lower low water.

Notwithstanding the large amount of rock dumped on this spur the stringers, bolted to the caps with 1-inch bolts, were washed off for a distance of 400 feet during one of the high tides of last winter.

This protection spur has now been built back for a distance of 1,488 feet.

PLANT.

The whole plant has been kept in good repair during the entire year. All new plant and repairs to plant, with the exception of the more extensive barge repairs, have been made on the works and in the workshops.

Barges, etc.—The rock-barges have all been more or less damaged while used in carrying rock to the work, but nothing of any serious nature has occurred.

The smaller repairs, consisting mainly in fixing up the guards and decks, have all been made here.

The four barges, Nos. 11–14, were repaired in Portland last winter.

Repairs consisted mainly in new deck-beams and decking.

All the other barges were laid up in winter quarters in Youngs River, and there painted and some smaller repairs done to them.

An old pile-driver flat-boat was thoroughly repaired on the beach here, having new gunnels, keelsons, deck-beams, decking, and pumps put in.

Six new skiffs were built to take the place of others broken while used with the barges.

Tug.—On the evening of November 1 fire broke out in the engine-room of the *George H. Mendell*, destroying the after-part of the cabin and engine connections and fittings in the engine-room above deck.

The origin of the fire is not known.

The *Mendell* was sent to Portland in tow of the steamer *Cascades* on the 2d and returned on the 5th sufficiently repaired to resume the towing of rock.

The stem of the *Mendell* was split by running into one of the barges, making it necessary to send the tug to Portland for repairs. This was done on January 16.

A steam-register was put in the pilot-house of the *Mendell*.

Locomotives.—In July a small locomotive was borrowed from Cascade Locks, as the three then in use here were not sufficient to keep up with the work to be done.

This locomotive was returned in November, when a new Baldwin locomotive, of same size as the others in use, was received.

There are now four locomotives used on this work.

In January and February, during suspension of active operations, all locomotives were put in thorough repairs, tested, and painted.

Two locomotives had entire sets of brasses renewed.

Hoisting-engines.—No other work than ordinary small repairs and painting has been necessary to do to these.

Flat-cars.—Three 8-wheeled flat-cars were built during the month of May. The wood-work in the trucks of three old cars was renewed.

All flat-cars were put in good repair during the winter months.

There are now nine flat-cars on the work.

Mat-cars.—One of these was built in August, as the number on hand, three, was not sufficient to keep the mattress-work up with the pile-driving.

Dump-cars.—Fourteen self-righting, geared dump-cars were built during the year and ten of these in January and February.

We now have fifty-two dump-cars for hauling rock out to the jetty. Twenty-two of these are the old style and the remaindor, or thirty, of the geared pattern.

The wood-work of five old dump-cars was entirely renewed.

All of the dump-cars have been more or less repaired during the progress of the work, and also during the winter months.

Push-cars.—Two of these were built; one for use in the car-shop and the other for transporting lighter material about the work.

Derricks.—One new derrick was made on the work and put up in place of one in use but not working satisfactorily.

Jetty tramway pile-driver, old.—The driver was overhauled after last season's work and machinery and wood-work repaired and painted. The hammer-drum was bored out and a new shaft for it turned and put in.

Jetty tramway pile-driver, new.—Work on the forgings for this driver was commenced late in November, but owing to snow blockades on the railroads the iron material was not received until March.

The following is a brief description of the construction and working of this driver:

The whole of the upper portion is mounted upon a car composed of trussed wooden beams, connected and bolted together, forming a strong rectangular frame-work 17 feet long and in width 19 feet, thus extending over and running on both tracks.

The car-frame is supported at each of the four corners by a double truck of eight wheels, making thirty-two wheels in all.

The axles run in brass bearings in pedestals, which are bolted to square frames of 7-inch channel-bars, and resting across the top of these frames are two 12-inch bars, from which are suspended the center pins of the trucks.

The two center pins of a pair of trucks extend down through and support a box-girder of plates and eye-beams about 6 feet long, and upon this girder rests the wood frame-work of the car.

Upon the car is a roller path 16 feet in diameter of 30-pound rail; a similar one, but inverted, is secured to the upper or revolving portion of the driver, and runs upon forty-eight steel rollers.

The upper portion consists of a braced platform supported at the ends by hog-stays, and carrying the gins at one end and the boiler, tanks, fuel, etc., at the other.

The pump is carried on a frame which is suspended over the side of the track; the steam for working it is passed through pipes which are connected by a flexible hose with couplings for detaching when the driver revolves.

Couplings are also provided on the water-discharge hose for the same purpose.

The discharge-hose (4½ inches) is connected to a Y-pipe which has 2½-inch branches, each having a gate-valve; the two pipes then lead upwards and connect with two lengths of hose passing over large pulleys running in a frame, which slides in vertical guides; the other ends have couplings to connect with the jet-pipes on the piles.

The jet-pipes are 1½ inches in diameter, two of which are secured to each pile by means of staples.

The method of working is as follows: The driver is revolved by means of a pinion and toothed segment until the gins are opposite the tender-car which contains material for construction.

A line is attached to the large end of the pile and passing over sheaves at the gin top leads to a drum on the engine. Another line is attached to the small end of pile and leads through a block on the gins, then down to a guide-pulley on the platform, and thence to a capstan-head on one of the engine shafts.

The pile is lifted horizontally off the tender-car, the driver is then revolved and secured in the required position, the small end of the pile is lowered and the line detached, leaving the pile suspended between the leaders.

The hose-pipes are then coupled to the jet-pipes, which have permanently fastened to each of them a short piece of chain terminating in a ring and dowel.

The ends of the chains are brought together and the dowels lightly driven into the pile; a 4-inch line is made fast to the rings and leading up, passes through a block on the gins; another smaller line is hooked to the rings and passing over guide-pulleys, depresses the hose pulley frame and relieves the hose-pipes from tension, when the pile sinks.

The pile is then let down to the bottom, the hammer is lowered and allowed to rest on the pile, the pump is started, and the pile sinks.

When the head of the pile has come within 5 or 6 inches of its required level the pump is stopped, the hammer raised, and the 4-inch line hauled up, pulling out the dowels and drawing up the two jet-pipes through the staples, clear of the pile.

A few light blows with the hammer bring the head of the pile to grade.

When a row of four piles has been driven a cap is bolted across, the stringers and rails are then extended, and the driver moved forward for the next bent.

In constructing this driver it was deemed advisable to reduce the load upon the wheels and also upon the rollers, and this has been done by increasing their number.

Besides the modification in the design of the trucks, no other departure has been made from the main features of the old driver, which has been working satisfactorily for several years.

BUILDINGS.

All buildings were whitewashed and roofs painted during the year.

A carpenter shed, 20′ x 50′, a lumber shed, 20′ x 50′, both at one of the old wharves, and a work-shed, 20′ x 50′, at the pile-driver tracks, were built.

Aside from the above nothing has been done to the buildings except some small ordinary repairs.

MISCELLANEOUS.

One 2,000-gallon water-tank was put up near the main track between the shop and round-house tracks, and is used exclusively to fill the tanks of the locomotives.

The jet-pump formerly used on the tramway pile-driver has had the cylinders bored out and otherwise repaired, and is kept in reserve in case of breakdown of the one in use.

Eight, number six, and two wrecking frogs, and a number of switch and draw-bars for "crossovers" on the tramway, were made on the work.

Accompanying this report are the following tables and drawings, viz:

Detailed statement of the principal work done and material received during the fiscal year.

Plan and profile showing the extent of jetty constructed June 30, 1890.

Drawing showing construction of jetty and jetty tramway.

Drawing showing method of making and sinking mats.

Drawing showing side-view of new pile-driver.

In conclusion, I desire to acknowledge the able and faithful assistance given me in my work by Mr. J. W. Stoneman, overseer, and Mr. A. S. Fleet, draughtsman.

Very respectfully, your obedient servant,

G. B. HEGARDT,
Assistant Engineer.

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

Detailed statement of the principal work done and material received during the fiscal year ending June 30, 1890.

Month.	Tramway constructed.	Tramway braced.	Mats replaced.	Rock received.	Fascines received.	Poles received.	Piles received.	Lumber received.
	Feet.	*Feet.*	*Feet.*	*Tons.*	*Cords.*	*Number.*	*Lin. ft.*	*Ft., B. M.*
July	1,284	1,504	1,690	14,316.5	1,283.43	2,432	14,820	262,975
August	1,436	1,728	1,536	12,430.5	1,127.78	1,242	22,680	173,176
September	1,088	1,128	1,214	10,879.8	1,178.09	2,843	23,160	131,489
October	1,168	1,256	1,036	15,229.7	989.38	3,538	13,745	106,626
November	528	912	900	12,505.1	576.19	.....	14,135	82,432
December	.....	192	60	9,503.0	188.82	.....	.....	71,912
January	.....	.....	.....	.....	.....	.....	.....	.....
February	.....	.....	.....	.....	.....	.....	.....	.....
March	.....	.....	.....	5,637,0	.....	.....	.....	.....
April	1,392	790	1,082	15,840.4	961,69	1,494	8,580	98,712
May	1,408	1,274	1,194	9,067.3	947.97	2,324	25,960	169,053
June	704	896	856	14,944.2	744.06	1,741	10,230	95,352
Total	9,008	9,680	9,568	120,353.5	7,997.41	15,614	133,310	1,191,727

COMMERCIAL STATISTICS.

The following statistics bearing upon the improvement of the mouth of the Columbia River were collected from the sources indicated, and are the most reliable that can be obtained.

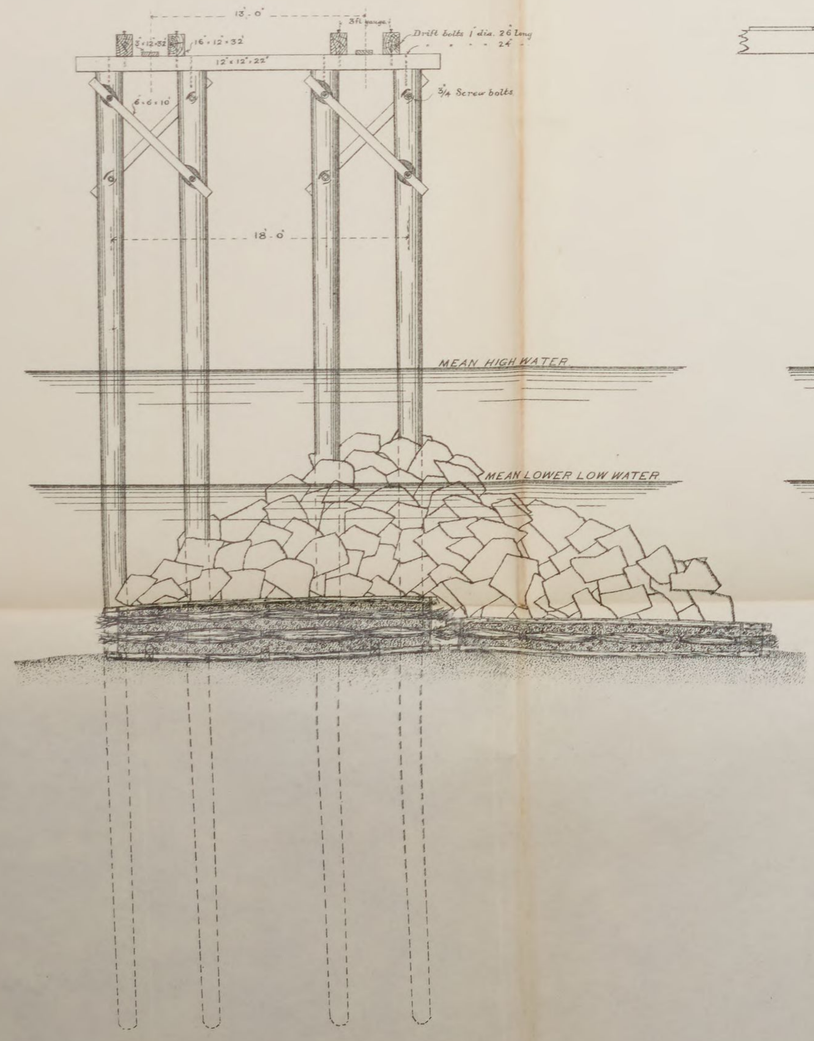
IMPROVEMENT

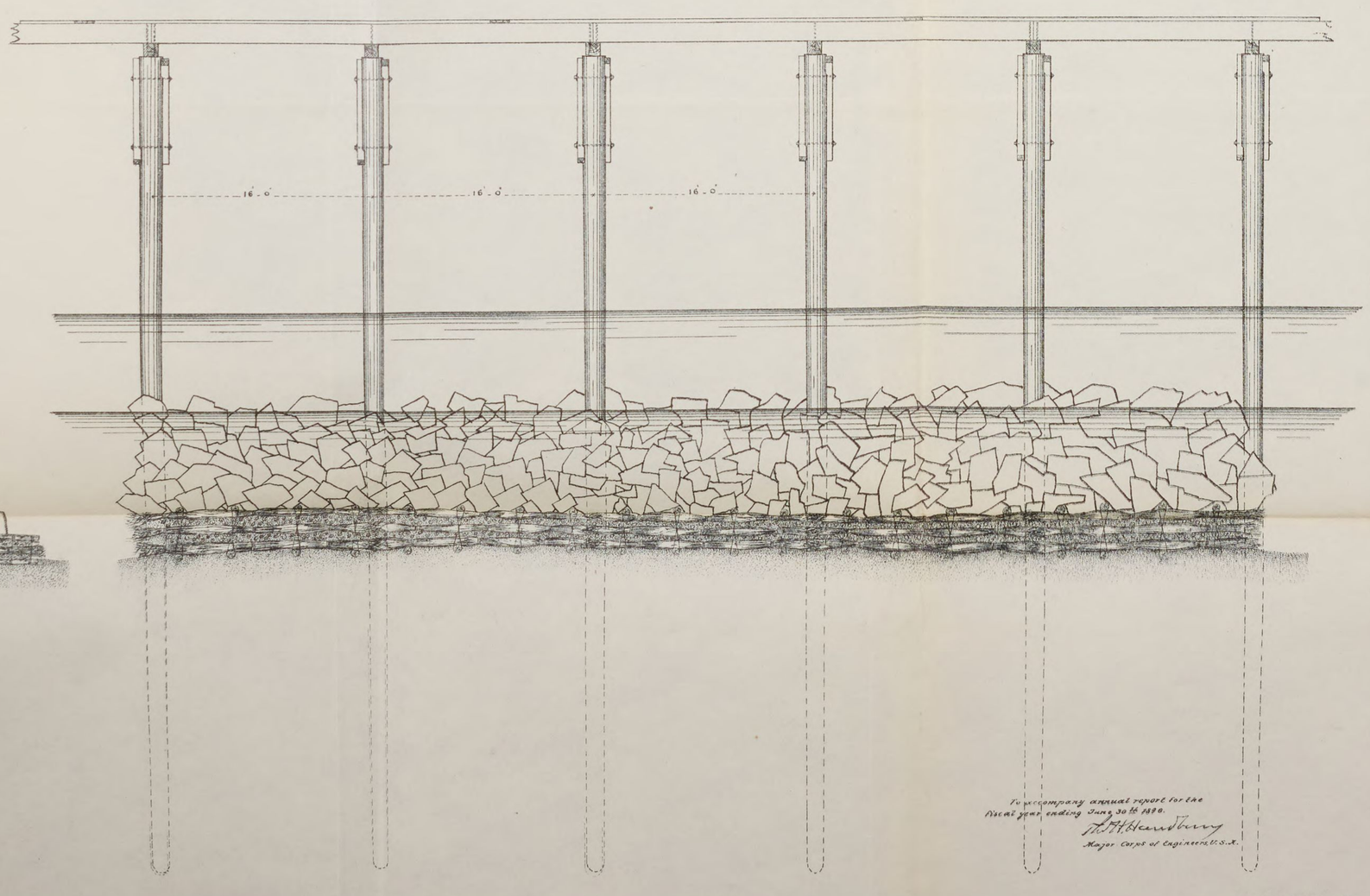
OF

MOUTH OF THE COLUMBIA RIVER.

JETTY AND JETTY TRAMWAY.

SCALE.





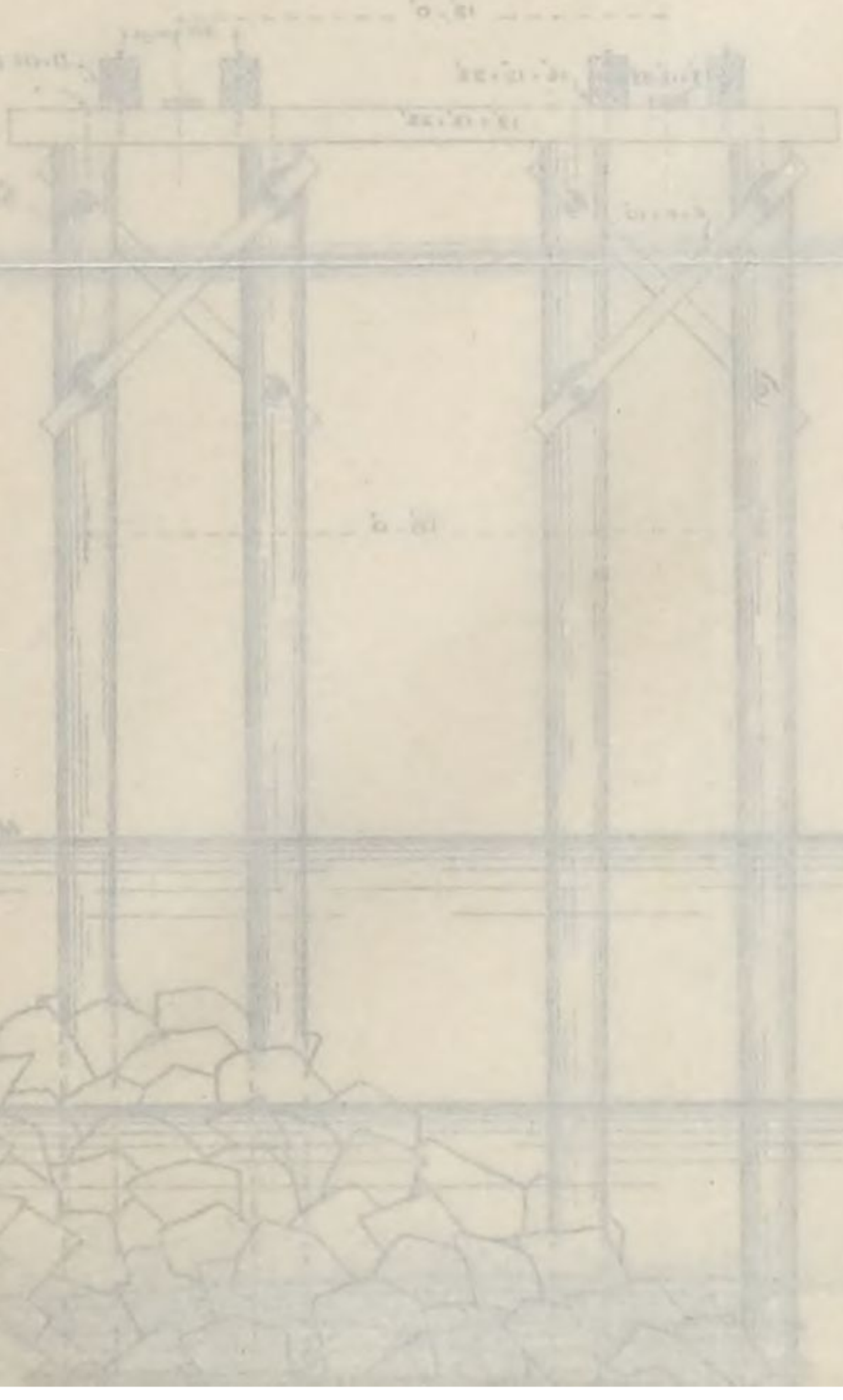
To accompany annual report for the fiscal year ending June 30th 1890.

H. M. Chittenden

Major Corps of Engineers U. S. A.

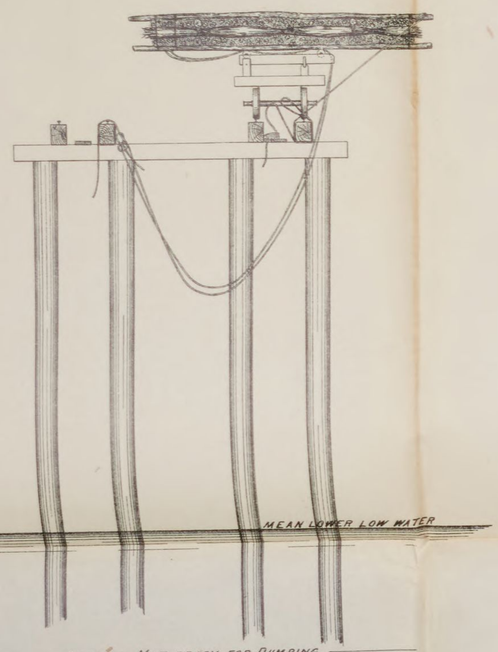
Photo-Lith. by A. HOEN & CO., Balto., Md.

PLAN SHOWING THE
JETTY AND

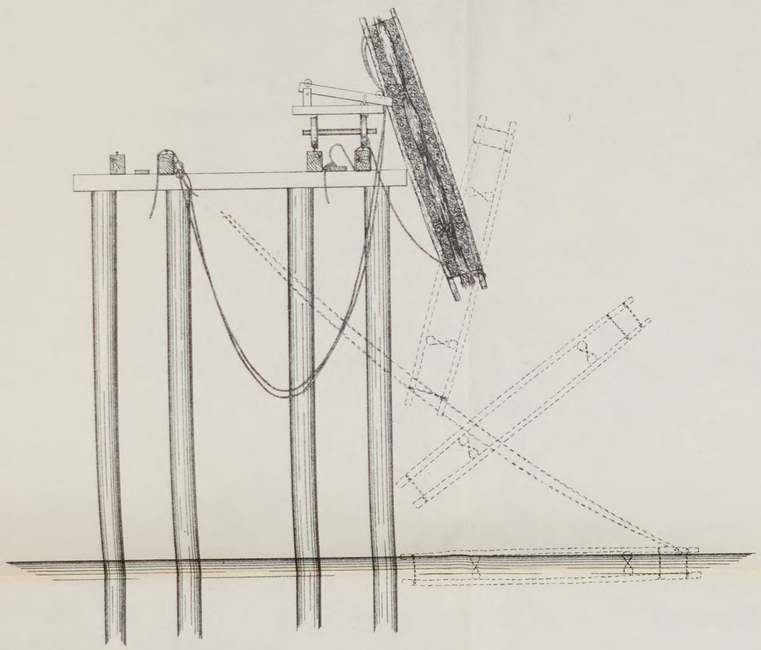


IMPROVEMENT
OF
MOUTH OF THE COLUMBIA RIVER.
MATTRESS WORK.

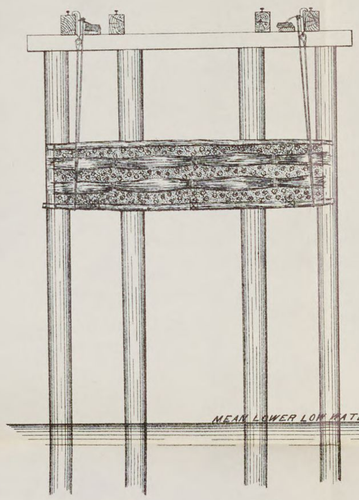
SCALE



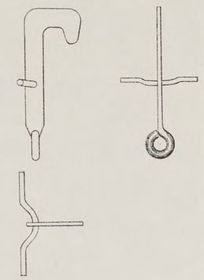
OUTSIDE MAT READY FOR DUMPING



OUTSIDE MAT BEING DUMPED

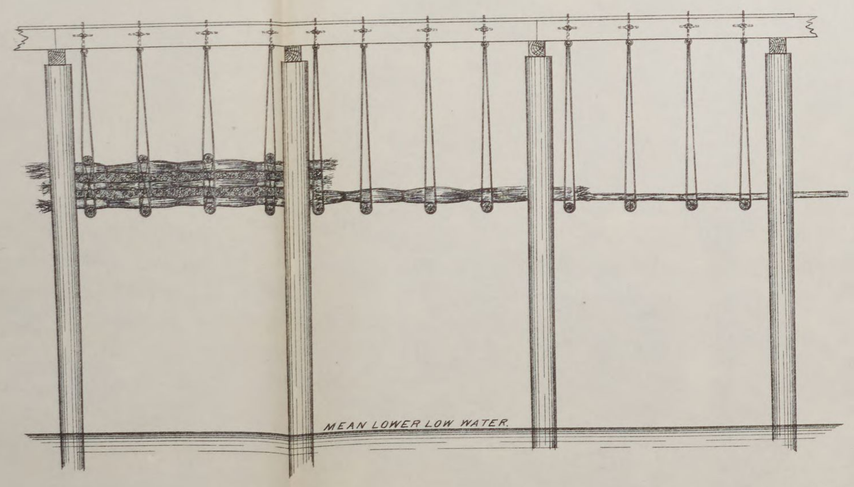


INSIDE MAT READY FOR LOWERING AND SINKING



MATTRESS HOOKS

SCALE

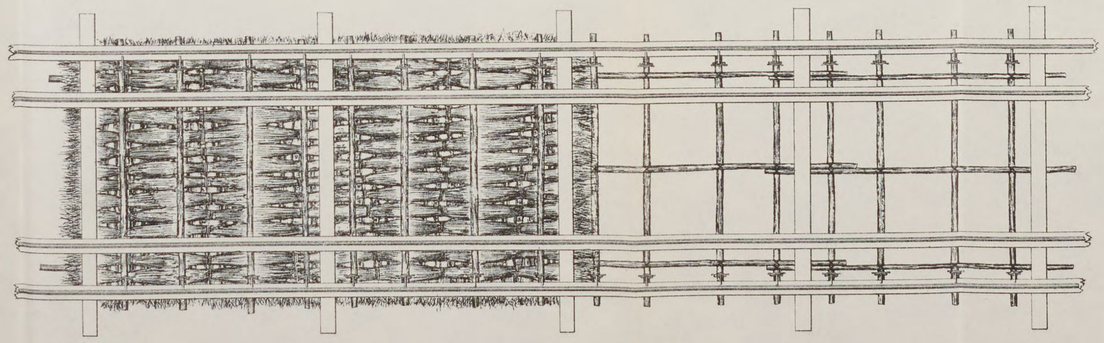


INSIDE MAT PARTLY CONSTRUCTED

NOTE.

OUTSIDE MATS ARE MADE 20'×20'

INSIDE " " " 20'×64'

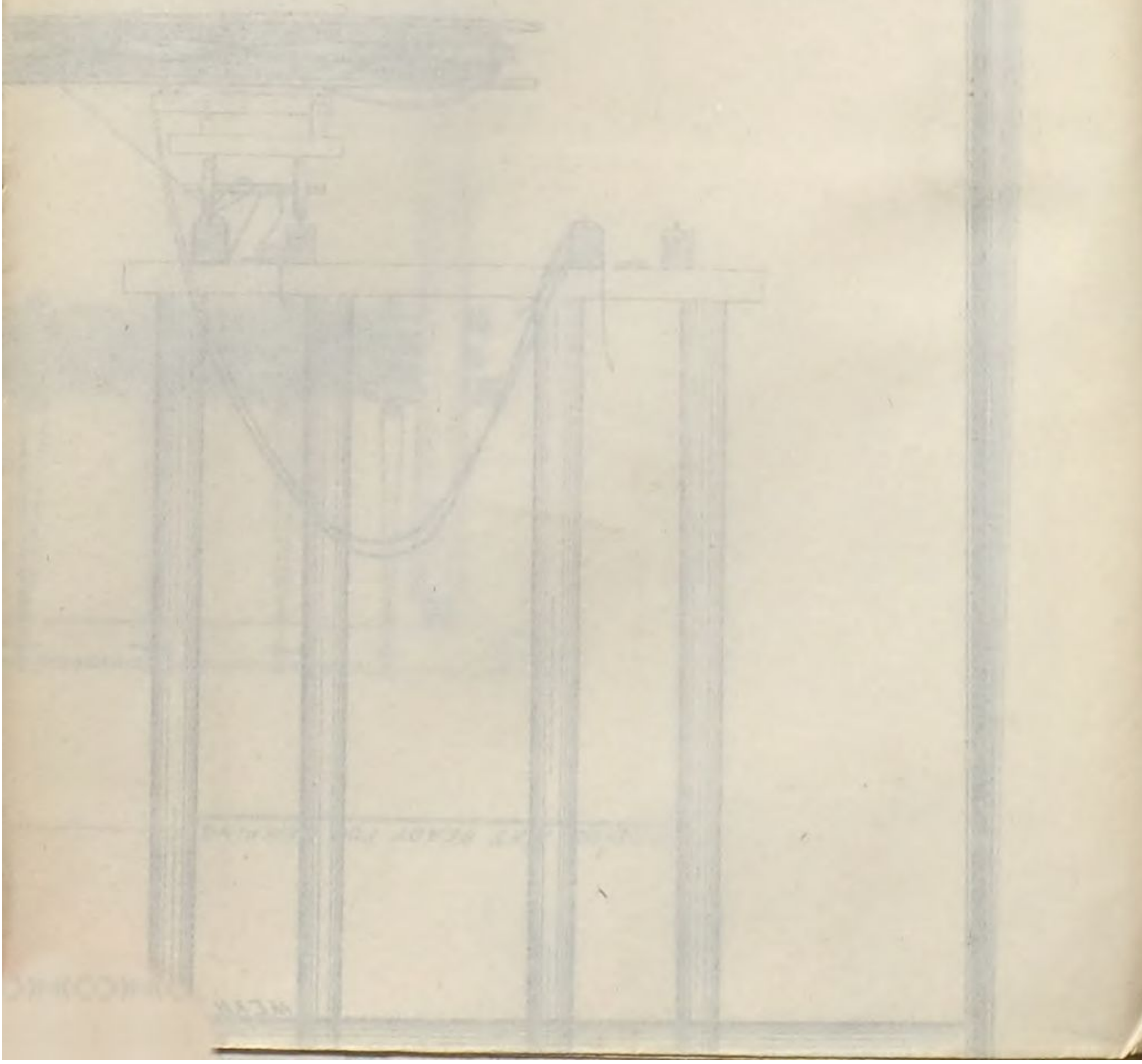


PLAN OF INSIDE MAT PARTLY CONSTRUCTED

To accompany annual report for the fiscal year ending June 30th 1890.

Major Co. of Engineers U.S.A

Photo-Lith by A. HOEN & CO. Balto. Md.



IMPROVEMENT

OF

MOUTH OF THE COLUMBIA RIVER.

REVOLVING PILE DRIVER

HYDRAULIC PROCESS

SCALE

0 10 20 30 FEET

To accompany annual report for the fiscal year ending June 30th 1880

Thos. H. Handbury

Major Corps of Engineers, U.S.A.

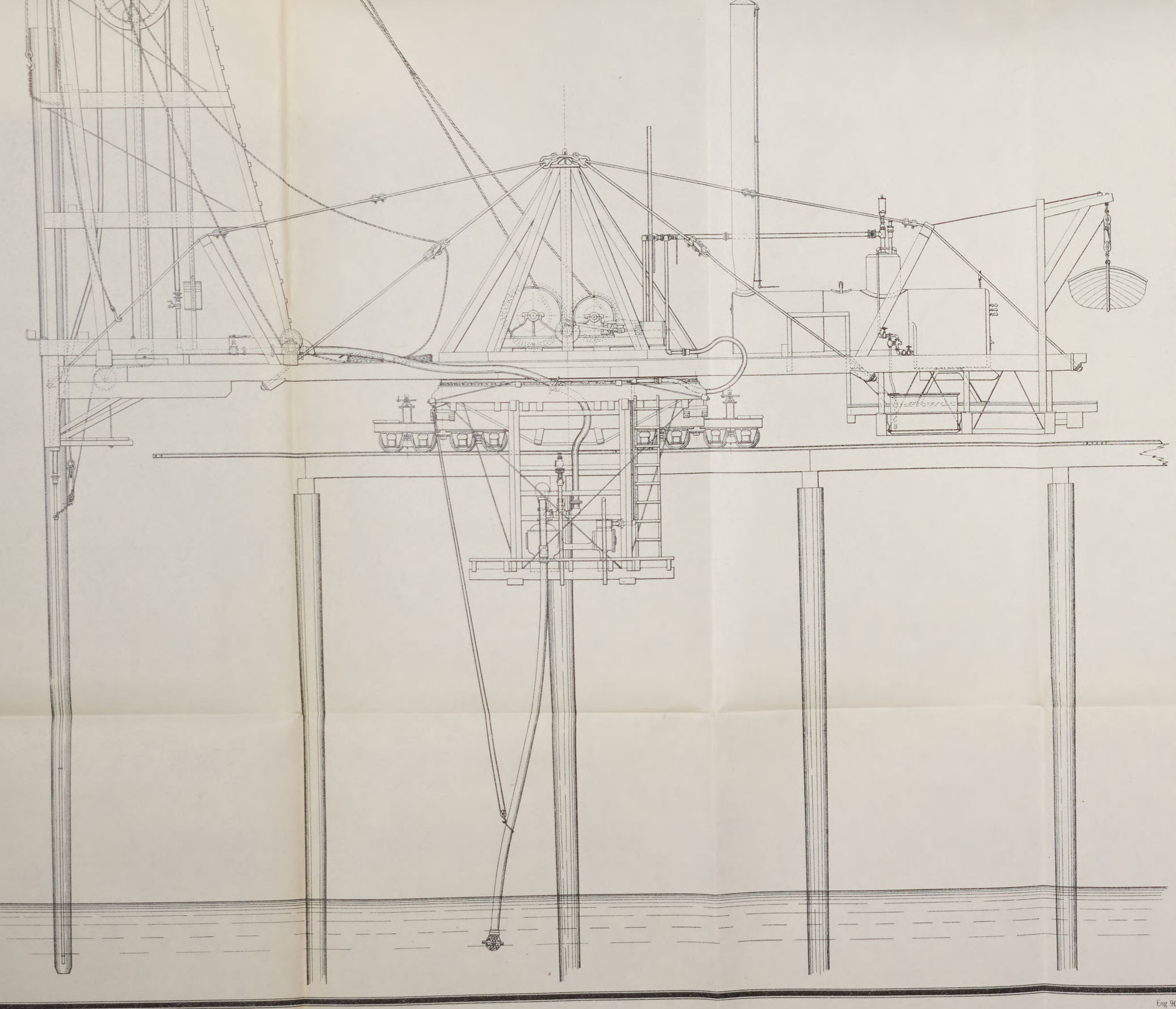


Photo-Lith by A. HOEN & CO., Balto., Md.

Eng 90.

Arrivals and clearances of vessels at Portland, Oregon, during the year ending June 30, 1890.

[From collector of customs, Portland, Oregon.]

Vessels.	Coastwise.		Foreign ports.				Total.	
			American.		Foreign.			
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Arrived in 1889 and 1890.....	218	243, 295. 05	3	2, 580	51	51, 882	272	297, 757. 05
Cleared in 1889 and 1890	192	212, 123. 24	31	21, 678	67	74, 725	290	308, 524. 24

Commerce, July 1, 1889, *to June* 30, 1890.

Exports	$3, 374, 129. 00
Imports (11 months only)	873, 858. 00
Duties collected	523, 027. 25

Total receipts, $534,015.89.

ARRIVALS AND CLEARANCES OF VESSELS, AND COMMERCE, AT ASTORIA, OREGON, DURING THE YEAR ENDING JUNE 30, 1890.

[From collector of customs, Astoria, Oregon.]

Vessels.	Coastwise.		Foreign ports.				Total.	
			American.		Foreign.			
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Arrived in 1889 and 1890.....	326	367, 108	11	4, 984	26	30, 673	363	392, 765
Cleared in 1889 and 1890	323	363, 562	21	14, 253	41	54, 151	385	422, 266
Arrived *via* Astoria for Portland ..	4	6, 703	8	5, 508	25	29, 449	37	31, 660
Cleared *via* Astoria from Portland .	3	4, 678	17	14, 120	41	54, 151	61	72, 949

Commerce, July 1, 1889, *to June* 30, 1890.

Exports	$1, 399, 713. 00
Imports	131, 519. 55
Duties collected	43, 329. 03

Total receipts, $45,681.51.

The gross annual tonnage passing in and out over Columbia River Bar, as reported by the collectors of customs at Portland and Astoria, is 1,416,311 tons.

[From report of Portland Board of Trade, September 29, 1889.]

Registered tonnage.—Inward, over Columbia River Bar, from August 1, 1888, *to July* 31, 1889.

Month.	Deep-sea vessels.								Steam.				Coasters, American.		Total.	
	American.		British.		German.		Norwegian.		American.		British.					
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
1888.																
Aug.	1	1, 339	3	3, 909	....	.....	....	.....	19	26, 835	....	.....	11	4, 218	34	36, 301
Sept	3	4, 378	9	10, 915	....	.....	....	.....	22	28, 286	2	2, 924	5	2, 616	41	49, 119
Oct.	1	1, 362	14	18, 516	....	.....	1	843	17	21, 865	2	2, 924	5	1, 702	40	47, 212
Nov	1	1, 296	13	15, 309	....	.....	1	901	17	24, 821	2	2, 924	6	2, 115	40	47, 366
Dec.....	....	.....	7	6, 860	....	.....	....	.....	19	28, 259	1	1, 462	5	1, 743	32	38, 324
1889.																
Jan.....	2	2, 935	3	3, 253	1	1, 038	....	.....	17	23, 353	2	2, 924	5	2, 234	30	35, 737
Feb.....	....	.....	9	10, 741	2	2, 113	....	.....	17	25, 274	1	1, 462	6	2, 231	35	41, 821
Mar	....	.....	5	6, 416	....	.....	....	.....	17	26, 510	1	1, 462	6	3, 113	29	37, 501
Apr	....	.....	3	2, 599	1	825	....	.....	19	23, 141	1	1, 462	8	2, 894	32	30, 921
May	....	.....	5	7, 050	....	.....	....	.....	18	22, 140	1	1, 462	6	2, 238	30	32, 896
June	....	.....	3	3, 160	....	.....	....	.....	23	26, 468	1	1, 462	9	2, 706	36	33, 796
July	1	1, 931	3	3, 755	....	.....	....	.....	25	26, 378	2	2, 924	5	1, 089	36	36, 077
Total ..	9	13, 241	77	92, 483	4	3, 976	2	1, 744	230	303, 330	1	23, 392	77	28, 899	415	437, 065
Previous season .	8	10, 656	95	117, 072	1	1, 726	2	2, 137	143	283, 747	4	2, 149	94	47, 068	347	465, 455

Registered tonnage.—Outward, over Columbia River Bar, from August 1, 1888, to July 31, 1889.

Month.	Deep-sea vessels.								Steam.				Coasters, American.		Total.	
	American.		British.		German.		Norwegian.		American.		British.					
1888.	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Aug	3	4,448	4	3,899	....	.....	....	.....	15	21,199	2	2,924	8	3,447	30	32,993
Sept	1	1,339	4	4,612	....	.....	....	.....	22	27,564	2	2,924	9	3,326	38	39,765
Oct	2	3,185	10	13,214	....	.....	....	.....	19	24,789	2	2,924	6	2,906	39	47,018
Nov	2	2,046	13	17,187	....	.....	1	843	16	24,059	1	1,462	5	1,777	39	48,836
Dec	1	1,362	10	11,624	....	.....	1	901	17	24,237	1	1,462	4	1,267	34	40,853
1889.																
Jan	1	1,296	8	8,104	1	1,038	....	.....	19	28,204	1	1,462	5	1,858	35	41,972
Feb	....	.....	2	2,700	....	.....	....	.....	17	23,550	1	1,462	4	1,924	25	29,636
Mar	1	1,899	5	6,160	2	2,113	....	.....	18	26,788	1	1,462	11	5,149	38	43,571
Apr	1	1,036	7	8,286	....	.....	....	.....	15	23,800	1	1,462	4	1,036	28	35,620
May	....	.....	4	4,793	....	.....	....	.....	22	24,615	2	2,924	8	3,577	36	35,909
June	....	.....	5	6,656	1	825	..	.....	22	25,439	1	1,462	6	1,707	35	36,089
July	...	.....	2	2,496	....	.....	..	.....	24	24,611	2	2,924	9	2,590	37	32,621
Total ..	12	16,611	75	89,731	4	3,976	2	1,744	226	298,855	16	23,392	79	30,574	414	464,883
Previous season.	3	3,857	98	122,344	2	2,350	2	2,137	139	282,651	5	2,352	97	51,234	346	466,925

Comparative statement of principal exports for the past eight seasons.

WHEAT.

Season ending July 31—	Foreign.		Domestic.		Totals.	
	Centals.	Value.	Centals.	Value.	Centals.	Value.
1882	3,704,992	$5,965,518	437,899	$711,900	4,142,819	$6,677,418
1883	1,761,754	2,918,458	362,709	560,338	2,124,463	3,487,796
1884	2,276,809	3,712,253	311,941	477,725	2,588,750	4,189,978
1885	3,147,902	3,720,378	521,834	598,828	3,669,796	4,319,203
1886	3,971,756	4,979,841	1,349,740	1,602,805	5,321,486	5,582,646
1887	3,042,316	3,889,499	711,872	988,936	3,754,188	4,878,435
1888	3,203,108	3,783,208	1,259,263	1,485,189	4,462,371	5,268,397
1889	2,689,686	3,779,644	559,953	741,642	3,249,639	4,521,286

FLOUR.

Season ending July 31—	Foreign.		Domestic.		Totals.	
	Barrels.	Value.	Barrels.	Value.	Barrels.	Value.
1882	526,003	$2,410,180	95,956	$443,612	629,991	$2,853,792
1883	353,829	1,684,919	139,471	708,854	493,300	2,393,773
1884	334,534	1,556,684	218,846	945,857	553,380	2,502,141
1885	198,208	796,839	182,316	656,485	380,523	1,453,324
1886	353,869	1,323,877	187,736	689,708	541,632	2,013,585
1887	383,773	1,412,208	137,908	548,447	521,681	1,960,655
1888	486,456	1,703,926	158,015	598,670	644,471	2,302,606
1889	510,875	2,037,725	144,184	584,186	655,059	2,621,911

SALMON.

Season ending July 31—	Foreign.		Domestic.		Totals.	
	Cases.	Value.	Cases,	Value.	Cases.	Value.
1882	308,824	$1,557,164	192,501	$981,767	501,325	$2,538,931
1883	367,388	1,940,991	280,944	1,460,181	648,332	3,401,172
1884	281,060	1,352,498	267,084	1,308,620	548,144	2,662,118
1885	296,285	1,228,441	363,583	1,494,315	660,138	2,757,756
1886	166,697	725,408	410,800	1,795,994	577,497	2,521,402
1887	159,707	816,707	372,112	1,925,590	531,819	2,742,297
1888	78,754	466,631	382,793	2,241,281	461,336	2,707,912
1889	107,240	732,805	270,535	1,903,593	377,775	2,636,398

Table of comparative values of exports for the seven years ending July 31, 1889.

Year.	Foreign.	Domestic.	Total foreign and domestic.
1882–'83	$6,553,227	$6,383,266	$12,936,493
1883–'84	6,638,850	6,014,321	12,653,171
1884–'85	5,857,057	6,699,776	12,556,833
1885–'86	7,032,026	9,480,996	16,513,022
1886–'87	6,196,722	9,507,183	15,703,905
1887–'88	5,991,990	8,788,887	14,780,877
1888–'89	6,634,989	9,562,815	16,197,804
Total	44,904,861	56,437,244	101,342,105

Comparative statement of deep-sea tonnage for the past six seasons.

INWARD.

Flag.	1883–'84.		1884–'85.		1885–'86.		1886–'87.		1887–'88.		1888–'89.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons*
American	17	21,064	17	22,044	14	19,169	9	11,839	8	10,656	9	13,241
British	72	71,121	97	91,737	132	137,138	130	113,837	95	117,072	77	92,483
Norwegian	2	1,386	.....	.....	1	901	.....	.....	2	2,137	2	1,744
German	1	417	4	3,613	3	2,622	2	1,475	1	1,726	4	3,876
Total	92	93,988	118	117,399	150	159,830	141	127,151	106	131,591	92	111,444

OUTWARD.

American	22	28,846	20	24,790	14	19,323	7	9,280	3	3,857	12	16,611
British	73	71,051	97	92,555	119	124,073	111	119,716	98	122,344	75	89,731
Norwegian	2	1,386	.....	.....	1	901	.....	.....	2	2,137	2	1,744
German	....	.....	4	3,618	3	2,622	1	851	2	2,350	4	3,976
Total	97	101,283	121	120,963	137	146,919	119	129,847	105	130,688	93	112,062

SPECIAL REPORT ON IMPROVEMENT OF MOUTH OF COLUMBIA RIVER, OREGON AND WASHINGTON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, December 10, 1889.

SIR: In order that you may be fully informed as to the status of the work of improving the mouth of the Columbia River on the latest date practicable, I have the honor to submit the following condensed report of operations covering the time from June 30 to November 30, 1889, the former date being that of my last annual report, which has been forwarded by you to the Secretary of War, and, with his report, submitted to Congress. Between that date and November 30 a large amount of work has been done.

A reference to the annual report will show that at the end of the fiscal year the outer end of the jetty tramway was at station 108+16, station 25+80 being always considered the root or shore end of the jetty. This gave the length of this tramway 8,236 feet, or 1.56 miles. The outer end is now (November 30) at station 163+20, an advance of 5,504 feet, or 1.04 miles, thus making the total length of the tramway proper 2.6 miles. Over this distance the mattress work required by the project has all been done. Rock sufficient to raise the jetty to the height of mean low water over about three-fourths this distance has been put in place and sufficient to securely hold the mattresses in place over the remaining fourth has been dumped upon them.

The following statement gives a résumé of the principal work done and material received from June 30 to November 30, 1889:

Month.	Tramway constructed.	Tramway braced.	Mattress work placed.	Rock received.	Fascines received.	Poles received.	Piles received.	Lumber received.	Coal received.	Wood.
	Feet.	*Feet.*	*Feet.*	*Tons.*	*Cords.*	*No.*	*Lin. ft.*	*Ft. B. M.*	*Tons.*	*Cords*
July	1,284	1,504	1,690	14,316.5	1,283.43	2,432	14,820	262,975	$200\frac{341}{2240}$	.....
August	1,436	1,728	1,536	12,430.5	1,127.78	1,242	22,680	173,176	.....	122.8
September	1,088	1,128	1,214	10,879.8	1,178.09	2,843	23,160	131,489	$168\frac{80}{2240}$	136.9
October	1,168	1,256	1,036	15,229.7	989.38	3,538	13,745	106,626	.....	.....
November	528	912	900	12,505.1	576.19	.....	14,135	82,432	$178\frac{375}{2240}$	.....
Total	5,504	6,528	6,376	65,361.6	5,154.87	10,055	88,540	756,698	$546\frac{896}{2240}$	259.7

This table takes no account of the work and material expended in making and preserving in good working order the large plant necessary to accomplish the work it represents.

It will be noticed that the tramway and jetty have been extended more than 1,000 feet farther since June 30 than was accomplished during the whole of last fiscal year, and also that more rock was dumped upon the jetty.

Our season for driving piles, extending jetty tramway, commences about April 1 and lasts until about the middle of November or 1st of December. This year the pile-driver was brought in November 20.

The rock can not be handled economically during the latter part of December, January, and February. At this time the river is liable to be frozen and rough weather to be experienced at the wharf where the barges are to be unloaded.

As exhibiting the principal work done and material received during the season extending from April 1 to December 1, 1889, the following table is submitted:

Month.	Tramway construction.	Tramway braced.	Mattress work placed.	Rock received.	Fascines received.	Poles received.	Piles received.	Lumber received.	Coal received.	Wood received.
	Feet.	*Feet.*	*Feet.*	*Tons.*	*Cords.*	*No.*	*Lin. ft.*	*Feet, B. M.*	*Tons.*	*Cords.*
Apr	640	690	1,006	7,446.4	681.16	.....	12,445	79,017	.....	.....
May	976	752	700	12,603.1	822.23	1,592	12,460	74,902	104	.....
June	1,184	832	980	14,820.6	966.97	1,964	27,355	216,936	100	129.6
July	1,284	1,504	1,690	14,316.5	1,283.43	2,432	14,820	262,975	$200\frac{341}{2240}$	.....
Aug	1,436	1,728	1,536	12,430.5	1,127.78	1,242	23,680	173,176	.....	122.8
Sept	1,088	1,128	1,214	10,879.8	1,178.09	2,843	23,160	131,489	$168\frac{80}{2240}$	136.9
Oct	1,168	1,256	1,036	15,229.7	989.38	3,538	13,745	106,626	.....	.....
Nov	528	912	900	12,505.1	576.19	.....	14,135	82,432	$178\frac{375}{2240}$	.....
Total.	8,304	8,802	9,062	100,231.7	7,626.23	13,611	141,800	1,127,553	$750\frac{896}{2240}$	389.3

Rails received, 210 tons.

There were constructed upon the works during this time eighteen dump cars, two mattress and three flat cars.

Special attention is invited to the fact that since April 1 the jetty tramway has been extended 8,304 feet, or nearly 1.6 miles.

The survey of the mouth of the Columbia River, recently made under your authority, shows that great and beneficial changes have taken place upon the bar since the survey of 1885, about the time of the com-

mencement of the construction of this jetty. The results of this survey are now being plotted, and it is expected that in the course of the present month the map will be finished and forwarded. The same channel depth over the bar which was available for a width of 1½ miles in 1885 is now available for a width of 5 miles, with indications that a much deeper channel is forming through about the middle of the bar. Very favorable results will be shown by this map.

In my annual report and also in the brief submitted by you to the Secretary of War it is mentioned that actual progress of a further extension of the jetty will cease about the 1st of December and can not be resumed until an additional appropriation is made available. After deducting amounts due on contracts and outstanding liabilities there is a present available balance on account of this work of about $79,000.

On present contract for rock delivered on barges at the quarry there is yet to be delivered about 40,000 tons. The contract was for 150,000 tons with an option of 150,000 more.

The funds available will be sufficient to receive the 40,000 tons rock and dump it upon the jetty, to finish the building of the new jetty pile-driver which is now being constructed to replace the old one, too much worn to risk the work of another season upon; to build ten new dump cars and thoroughly repair all the old cars; to make extensive repairs to four barges and to the steamer *Cascades*, which has done a great deal of hard work since February last; in short, to put all the plant in thorough order and get all the additions thereto that will probably be required until the completion of the work.

If additional funds can be provided that may become available, say about the 1st of April, everything will be in readiness to push the work forward during the next season even more rapidly than it has advanced during the last. With an early start in the spring and plenty of available funds with which to push the work there does not now seem to be any reason why the jetty tramway may not be pushed out if necessary to the extent of the 4½ miles contemplated by the project as the extreme limit of the jetty.

Until a further supply of funds is provided no arrangements can be made for the piles, lumber, railroad iron, and other material necessary to the tramway, nor can anything be done towards procuring the large quantity of brush and rock that can be used upon the jetty during the season.

Every day's delay in the spring in using to its full capacity the large plant that has necessarily been provided for this work will result in a pecuniary loss to the Government, as well as a detriment to the work. It will bring discredit upon the Government methods and excite criticism throughout the country. Should additional funds be delayed until near the close of the long session of Congress, late in the summer, a whole season will be practically lost and the jetty tramway, which is the main feature, on which the economic success of the work depends, will be that much longer jeopardized in the winds and waves of the ocean. This is a frail structure built upon the sands in the ocean, as a means on which the rock and other material for the jetty is to be rapidly transported to their place of deposit. It can not be expected to remain a great length of time in its exposed condition, hence we should use it while we may. When once destroyed the expense of replacing it will be much greater than that of the original structure.

In view of the present status of this work, and of the great interests that are involved in its success, and of the large expense that any delay in its completion will incur to the Government, I respectfully suggest

that every means proper to the Chief of Engineers' Office be used to call the attention of Congress to the necessity of an early appropriation for its further prosecution.

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, U. S. A., Pacific Division Engineer.)

[First indorsement.]

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., December 14, 1889.

Respectfully forwarded.

Unquestionably both engineering and economical considerations favor resumption of work on the jetty about April 1, 1890, and its continuous prosecution thereafter during working seasons.

The views of Major Handbury are concurred in.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

REPORT OF THE BOARD OF ENGINEERS ON OVERCOMING OBSTRUCTIONS TO NAVIGATION IN THE COLUMBIA RIVER AT THE DALLES AND CELILO FALLS, AND AT THREE AND TEN MILE RAPIDS.

WAR DEPARTMENT,
Washington City, December 14, 1889.

The Secretary of War has the honor to transmit to the House of Representatives, in compliance with the river and harbor act of August 11, 1888, a letter from the Chief of Engineers, transmitting a copy of the report of the Board of Engineer Officers convened to examine the obstructions to navigation in the Columbia River and The Dalles and Celilo Falls, and at Three and Ten Mile Rapids, in the State of Oregon.

The recommendation of the Board is concurred in by the Chief of Engineers and by this Department.

REDFIELD PROCTOR,
Secretary of War.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 13, 1889.

SIR: The river and harbor act of August 11, 1888, section 13, authorizes and directs the Secretary of War to appoint a board of three engineers from the United States Army, whose duty it shall be to thoroughly examine the obstructions to navigation in the Columbia River, at The Dalles and Celilo Falls, and at Three and Ten Mile Rapids, and requires a report as to the feasibility and advisability of overcoming such obstructions by means of a boat railway at The Dalles and Celilo Falls and by widening to a navigable status for large tonnage

river boats the channel of said river at Three and Ten Mile Rapids, accompanied by careful and detailed plans, with estimates of the cost and a statement as to the usefulness of such improvements to navigation and of their relations and value to commerce; and the board is also required to report as to any other plan or project for overcoming said obstructions at said points, whereby said obstructions to navigation may be removed, which, in the judgment of the board, may be deemed either more desirable than the above or worthy of consideration by the Secretary of War and Congress.

In a preliminary report, dated December 18, 1888, the board, after discussing the various projects presented, concluded that a single-track portage railway, estimated to cost $431,500, which could be constructed in one year, would undoubtedly be the *quickest* and *cheapest solution* of the existing difficulties.

Recognizing that this project is not free from objection, in that it requires trans-shipment of freight, and that while adequate for present demands it may not answer future requirements, the Board has, as directed in the act of August 11, 1888, caused to be prepared a second project, which it now recommends as a final solution of the problem.

In this project boats are taken from the river at the foot of The Dalles Rapids, and are returned to the river at the head of Celilo Falls by means of hydraulic lifts, one at each terminus, and are transported over the intermediate distance on a railway a little more than 8 miles in length.

The estimate of cost of the whole system, with equipment of two cars and four engines, capable of passing eight boats of 600 tons weight loaded in each direction in twelve hours, including necessary buildings and 10 per cent. for contingencies, is $2,690,356.35. Estimate for Three-Mile Rapids is $170,000, making an aggregate of $2,860,356.35. It is estimated that a further expenditure of $716,000 in buildings, cars, engines, and side tracks will afford the maximum capacity of forty boats each way in twenty-four hours.

The annual cost of maintenance to pass sixteen boats in twelve hours is estimated to be $80,000.

A third project for overcoming the obstructions to the navigation of the Columbia at this point was presented in the early report of the Board, dated December 18, 1888, and in the project of Major Handbury for locks and canals, at a cost of $3,754,355, which sum the Board thinks will have to be materially increased.

Further objections to this plan are found by the board in the estimated cost of improvement of the Ten Mile Rapids, in their judgment placed too low, and in the necessity for extensive works for the water supply of the summit level. Hydraulic lifts at the termini of the canals might diminish the quantity of water needed at the summit level and the cost of the necessary excavation, but even with these modifications the Board does not consider this project the best method of overcoming the obstruction to navigation in this locality.

My views upon these projects are that ordinarily the best method for passing such obstructions as exist in the Columbia at The Dalles is by means of locks and canals, but in this case the objections presented by the Board as to cost and other difficulties would make me hesitate to recommend their construction. The immense production of grain in the valley of the upper waters of the Columbia and its tributaries is well known, but the cost of handling this grain and other farm products at the upper end of a portage railway from the boats to the cars, and at the lower end from the cars to the boats, would soon eat up the profits

of the farmers, and would in the end amount to an enormous tax upon their industry.

This objection of the Board to this system of construction is well taken, and would seem to throw out, if for no other reason, the building of a portage railway.

The remaining device, the boat railway, as recommended by the Board, is, in my judgment, feasible, and appears to be the best solution of the problem presented.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

REPORT OF THE BOARD.

GENERAL: The Board of Engineers constituted by Special Orders No. 38, from the Headquarters Corps of Engineers, series of 1888, has the honor to submit the following report:

The Board was appointed in obedience to the requirements of the river and harbor act of August 11, 1888, which provided that—

> The Secretary of War is authorized and directed to appoint a Board of three Engineers from the United States Army, whose duty it shall be to thoroughly examine the obstructions to navigation in the Columbia River at the The Dalles and Celilo Falls and at Three and Ten Mile Rapids, and to report to the Secretary of War, on or before the first Monday in December next, as to the feasibility and advisability of overcoming such obstructions by means of a boat railway at the Dalles and Celilo Falls, and by widening to a navigible status for large tonnage river boats, the channel of said river at Three and Ten Mile Rapids, accompanied by careful and detailed plans, with estimates of the cost, and a statement as to the usefulness of such improvements to navigation and of their relations and value to commerce. And said Board shall also report at the same time as to any other plan or project for overcoming said obstructions at said points whereby said obstructions to navigation may be removed, which, in the judgment of said Board, may be deemed either more desirable than the above or worthy of consideration by the Secretary of War and Congress, and shall report detailed plans, with estimates of the cost of such proposed improvement or improvements, and as to their relations to commerce and usefulness to navigation; and said Board shall report which of said projects is by it deemed most advisable. And the Secretary of War shall transmit said report to Congress, at its next session, with his own views and those of the Chief of Engineers of the United States Army thereon; and the sum of fifteen thousand dollars, or so much thereof as may be necessary, is hereby appropriated to defray the cost of making said examination and survey and the expenses of said Board.

The Board met at Portland, Oregon, August 21, 1888, where public sessions were held, and all persons interested were invited by letter and advertisement to present their views, orally or in writing, in order that the subject might be freely and thoroughly discussed and data obtained bearing upon the value and importance of the proposed improvement to commerce.

After carefully considering the material thus obtained, examining the locality, and studying the maps and papers relating to the subject that had been already prepared, the Board adjourned to await the collection of additional information and the preparation of detailed estimates of the cost of several methods suggested for the improvement.

The second meeting took place in Washington, D. C., November 26, 1888, as early a date as the new plans and estimates could be prepared.

These were carefully discussed and the Board submitted a preliminary report, presenting the several methods proposed for overcoming the obstructions to navigation in the Columbia River from Celilo to and including The Dalles, Ten Mile and Three Mile Rapids. These may be summarized as follows:

(1) By means of locks and canals, and improving certain portions of the obstruction for open-river navigation.

(2) By means of two boat railways to pass the two principal obstructions at The Dalles and Celilo Falls, without improving the intervening river.

(3) By means of a portage railway extending from the foot of Three Mile Rapids to above Celilo Falls.

In its report the Board expressed the opinion that a single-track portage railway, estimated to cost $431,500, which could be constructed in one year, if the funds were provided in time, would be the cheapest and quickest solution of the existing difficulties. It is applicable to all stages of the river, and with single terminal inclines would be adequate for present requirements, and with double terminal inclines, which can be constructed at small cost, its capacity could be largely increased, should commerce demand additional facilities. The objection to this method is the necessity for trans-shipment; but in view of the change in the character of the river navigation at this locality, described in the report, this objection loses part of its force. An appropriation of the sum estimated for the portage railway was recommended to afford speedy relief, the railway to be replaced by a more satisfactory solution when occasion requires it. At such a time this road would be a valuable aid during the new construction and would materially reduce its cost.

The law providing for the Board, from its comprehensive character, apparently intended that this investigation should be exhaustive, and that a plan should be presented that would meet all the future and possible demands of commerce. The Board at the time of submitting the report had not been able to give, in the brief interval the subject had been before it, the study required to prepare such a plan. It further proposed to examine hydraulic vertical lifts, their operations, and adaptability to the locality for use in place of the flight of locks in the canal projects, or the inclines in the boat railway project, and also to ascertain the advisability of connecting the two proposed boat railways by a track to reduce the number of inclines or lifts, to avoid removing the boat from the water more than once during a single transit, and obviate the necessity of improving Ten Mile Rapids, which will be costly, and which, in the opinion of the Board, is an essential feature of any plan contemplating their navigation.

Major Jones was requested to prepare, in connection with the boat railway project submitted with the previous report, a plan for uniting by a track the two boat railways proposed by him, together with an estimate of its cost. In the mean time, under instructions from the Secretary of War, the Board proceeded to England, Scotland, France, Germany, and Belgium, to examine the construction and method of operating hydraulic vertical lifts and inclined planes there in use.

The Board visited the double hydraulic lifts at Anderton, England, Les Fontinettes, France, and La Louvière, Belgium, witnessed their workings, and examined the drawings and working model of a single vertical lift at Magdeburg, Germany. It also visited the Victoria Lifting Dock, London, England, and the inclined planes at Meaux, France, and upon the Monkton Canal, near Glasgow, Scotland.

HYDRAULIC VERTICAL LIFTS.

The three double hydraulic lifts mentioned are similar in general design, the caisson or box carrying the boat afloat being supported upon a single central ram, and at each locality they are operated in pairs, the descending caisson containing a surcharge of water raising the ascending one by its greater weight. This is accomplished by connecting the hydraulic presses of the two rams by a pipe provided with a valve, which regulates the flow of water from one to the other. As the ascending caisson approaches the upper level this valve is closed, and the pressure upon its ram is increased by opening communication with an accumulator, which is pumped up by engines provided for the purpose.

The following table gives the principal dimensions of these lifts:

	Anderton.	Les Fontinettes.	La Louvière.
Dimensions of caisson:			
Length	75′	129′ 7″	141′ 1″
Width	15′ 6″	18′ 4½″	19′ 0½″
Depth of water	4′ 6″	6′ 6¾″	7′ 10½″
Cast-iron ram:			
Diameter	36″	78¾″	78¾″
Thickness	1¾″	2.362″	3″
Presses:			
Length	65′	49′ 2″	64′ 3½″
Interior diameter	37½″	80.2″	81″
Thickness	3½″	2.28″	6″
Height of lift	50′ 4″	43′ 1″	50′ 6½″
Displacement of boat, tons	100	250	400
Total weight lifted, do	240	785	1037
Pressure due to weight, atmospheres	38	25	32
Depth of surcharge	6″	12″	10″
Weight of surcharge (normal), tons	17	65	62
Actual time of lift, minutes	2½	5 to 7	2½
Total time of passing one boat up and another down, including entering and departure, minutes	8	20	15
Accumulators:			
Ram, diameter	1′ 9″	.....	1′ 7¾″
Length of stroke	13′ 6″	.....	25′ 3″
Proportion of stroke of main ram equal to full stroke of accumulator ram	4′	.....	15¾″

The details of these lifts are different in many respects. The Anderton lift, the first constructed, was opened to traffic in 1875, and has been continuously in use since, except during 1882, when one of the presses burst. This accident was fortunately attended with no material injury beyond damage to the press. At this lift the caisson is raised out of the aqueduct or canal which connects the lift with the Weaver River, and it is therefore water-borne. When the accident occurred the caisson containing a boat had just been raised, and the gate at the end of the cassion next the canal was partially opened. The caisson fell to the bottom, but beyond injuring the rudder and doing some slight damage to the upper works of the boat, caused by the sudden rushing in of the water from the aqueduct through the partly opened gate, no other damage occurred to the boat or lift. In making the repairs the thickness of this press, which was of cast-iron, was increased from 2.5 inches to $3\frac{1}{4}$ inches; and the communicating pipe between the two presses, which was originally 5 inches in diameter at its junction with the presses, was made to connect with the presses through steel boxes, from each of which four steel pipes, 2 inches in diameter and one-half inch in thickness, enter each press head at different levels and portions of its circumference.

The accumulator of this lift has to be used twice during the ascent

of a caisson; first, to begin the upward movement and start the syphons, which remove part of the water from the ascending caisson and create a surcharge in the descending one; and again, to continue and complete the ascent as soon as the descending caisson begins to lose part of its weight by entering the aqueduct below. The accumulator can also be used to make up any loss of weight in the surcharge due to a change in either pool-level of the canal.

At Les Fontinettes and La Louvière the caissons descend into dry chambers, and therefore retain their weight until the end of the stroke, and the accumulators are small and only necessary for supplying the water lost by leakage from the presses, and making up any loss of weight in the surcharge due to variable pool-levels. These accumulators also raise the gates of the caissons and canals, and at La Louvière drive capstans, which haul boats in and out of the caissons at both levels. They are supplied by pumps and turbines, actuated by water from the upper canal level. The presses at Les Fontinettes are copper cylinders, 0.118 inch thick, with exterior weldless steel coils 2.165 inches thick. The presses at La Louvière are cast-iron, 4 inches thick, hooped with continuous weldless steel coils 2 inches thick.

The four angles of the caissons at Anderton are cast-iron brackets, which move as the caisson ascends or descends, in close proximity to cast-iron vertical pieces or guides, supported by hollow cast-iron columns resting upon concrete blocks. By means of these brackets it is intended to check any movement, either laterally or longitudinally, that may take place during the motion of the caisson; but as yet the departure in either direction from the vertical during operation has been so slight that the guides have not been needed. The tops of the cast-iron columns are connected together by iron lattice work, which bears a foot-way around the outer edge of the caissons in their elevated positions.

The guides at the forward end of the caissons are dispensed with at Les Fontinettes lift, and the caissons are kept in place by two central guides and guides at the ends of the caissons next to the upper level. The caissons at La Louvière are provided with central guides, as well as guides at the four corners.

At both Les Fontinettes and La Louvière the surcharge of water is obtained in the elevated caisson by checking its ascent when the surface of the water in the caisson is a few inches below that in the upper level of the canal. The gates are then slightly raised, and the water is allowed to assume gradually the same level in the caisson as in the canal. When this is accomplished the gates are wholly raised, the boat passes out, and the caisson is surcharged ready for descent.

The time of passage of the boat from one level to the other is about 8 minutes at Anderton, of which two and one-half minutes only are taken for elevating the caisson, the remaining five and one-half minutes being consumed in passing the boat into and out of the caisson. The lift being double, two boats, one up and the other down, can pass at the same time, and it has the same capacity as two locks placed side by side for passing boats in opposite directions. At Runcorn, where the same difference of level is overcome on the same canal by a flight of locks, it requires one and one-half hours to pass a boat in one direction.

At Les Fontinettes lift two boats pass in opposite directions in about twenty minutes, the operation of the lift consuming from five to seven minutes. This lift is placed near a flight of locks where it sometimes requires two and one-half hours to pass a boat. Lately this time has been reduced to one and three-fourths hours.

La Louvière lift, which has recently been completed, is one of four

lifts to be constructed to overcome a difference of level of 220 feet. This is to be done by three double lifts of about 56 feet each, and one of about 50 feet. The last is the one constructed, but it can not be used until the others are built. The time of passage of a boat or two boats going in different directions at this lift will be about fifteen minutes. It is provided with two turbines and four pumps, calculated to furnish 5,275 English gallons of water per hour to the accumulator under a pressure of 40 atmospheres. Should one of the presses become temporarily disabled, the other can be operated by means of this accumulator, and boats pass through the canal.

The cost of construction of these lifts was as follows:

Anderton:	
Metal portion	$147,500
Foundations and masonry	92,500
Total	240,000
Les Fontinettes:	
Metal portion	160,000
Foundations and masonry	220,000
Total	380,000
La Louvière:	
Metal portion	170,000
Foundations and masonry	80,000
Total	250,000

At Anderton and Les Fontinettes the local conditions required an unusual length of iron aqueduct connecting the upper level of the canal with the lift, and at the latter great difficulty was experienced with the foundations, which consisted of layers of shingle and quicksand. The canal locks upon the Canal du Centre, Belgium, with a lift of about 14 feet, cost about $68,000 each, or a single flight of four of them, with a total lift of 56 feet, $272,000. This is rather more than the cost of the Anderton and La Louvière elevators, whose lifts are 50 feet 4 inches and 50 feet 6¼ inches, respectively, and are both double.

During the operation of the lifts the amount of water that is necessarily taken from the upper canal level is very small, and may be restricted, as at Anderton, where water is scarce, to that contained in the space of 2 feet or less between the gate at the end of the canal and the gate at the adjacent end of the caisson and the unavoidable leakage at the gates, which has been reduced to much less than is usual at lock-gates.

If the traffic is principally from the upper to the lower level the use of lifts will transfer water from the lower to the upper level through the difference of the displacement of the boats in the two caissons, and the amount thus elevated may exceed the amount removed from the upper level by the loss between the gates and leakage. In each operation of passing a boat through a lock, whether up or down, full or empty, the loss of water from the upper pool is measured by the product of the length, breadth, and lift of the lock, less the displacement of the boat. With a single flight of several locks, all of the same lift and dimensions, the average quantity of water drawn from the upper level is greater for the passage of a boat than with a single lock; and if the flight be doubled the average quantity withdrawn will also be doubled.

The principal advantages in favor of hydraulic double vertical lifts, such as have been described and used in connection with canals, as

a substitute for flights of locks, are economy of time and water, and when the local conditions are favorable they may be constructed with less cost. Experience has also shown that they can be operated with less expense. On the other hand, when once built the hydraulic lift does not admit of enlargement, as does the ordinary lock.

PETRI SINGLE VERTICAL LIFT.

In this lift the elevating power is the buoyant effort of water. It is provided with an iron or steel caisson, in which the boat is raised or lowered afloat, similar to those in the lifts that have been described. The caisson is supported upon a number of vertical iron columns of suitable length for the height of the lift, resting upon two iron or steel cylindrical floats. These latter supply the elevating power. When a boat is to be lowered the floats are forced down into a chamber or pit filled with water by four hydraulic presses, working in four vertical iron towers alongside the moving caisson. These presses act upon the ends of cross-bars resting upon the top of the floats, and hold the floats in their depressed position until the boat passes from the caisson into the lower level of the canal. When a boat is to be transferred to the higher level, it passes into the caisson from the lower level. The pressure upon the presses is then relieved, and the floats rising, elevate the caisson to a height sufficient to permit the boat to pass into the upper level. Should the lower canal level vary, the depression of the lift can be regulated accordingly by the presses. As the success of the entire construction depends upon the cylinders and their floating capacity, great care must be exercised in their preparation.

A lift of this character being single, it is probable that it could be constructed with less cost than those of the type heretofore mentioned. The amount of excavation required is considerably greater, however, on account of the large-sized chamber or pit necessary to accommodate the floats and permit them to settle to a depth sufficient to allow boats to pass from the caisson into the lower level. Its capacity for traffic when constructed would be equal to that of a flight of single locks, with a great saving of time and water. This lift was designed by Oscar Petri, civil engineer, at present technical attaché of the German legation in the United States.

VICTORIA LIFTING DOCK.

This dock is 310 feet long and 60 feet wide, and was constructed for lifting vessels requiring repairs. It is lifted by thirty-two hydraulic presses, arranged along its two sides, 20 feet 8 inches apart from center to center, and located in cast-iron columns. These columns being securely fastened together at their tops on each side, act as guides to the cross-heads of the presses, which move in slots from the top of the presses to the top of the columns.

The load is borne upon thirty-two girders, 65 feet long, which extend in pairs from side to side of the dock, being suspended by wrought-iron bars from the two ends of the cross-heads of the opposite columns.

The diameter of the rams, which are solid cast-iron, is 10 inches; the interior diameter of the presses, 11.5 inches, and the length of the stroke, 25 feet. The latter is effected by pumping directly into the presses under a pressure of 2 tons per circular inch. The dock has a lifting capacity of 5,750 tons, in addition to 650 tons, the weight of the rams, cross-heads, bars, and guides.

THE DOCK OF THE UNION IRON WORKS.

The hydraulic lift dock at the Union Iron Works, San Francisco, was begun in January, 1886, was opened for business on the 1st of July, 1887, and has been in constant operation since that time. The amount of shipping lifted to this date is very close to 1,000,000 tons. The site of the dock is over a mud flat, the depth of mud being about 100 feet from the top of wharf. This was dredged out to a depth of 32 feet below mean high water. The dimensions of the dock platform are length 435 feet, width 65 feet, width between centers of cylinders 72 feet. The foundations consist of seventy-two clusters of piles, fourteen piles in each cluster. These are driven inside of cylinders 5 feet diameter and 36 feet long. Each cylinder had a cast-iron shoe piece on the lower end, to which a 20-inch by 20-inch by 65 feet timber was bolted, extending from the cylinder on one side to the cylinder on the other side of the dock. The two coupled cylinders were then lowered in guides, the bottom edge sinking into the mud to the proper depth. When all the cylinders were ready the piles were driven inside, the mean length of piles being 105 feet. The piles were then finished flush on top, and the cast cap fitted and bolted to the angle iron on the top of the cylinders. It is considered that the piles are thus protected from the ravages of the teredo. On the two rows of piers thus formed, longitudinal girders are fitted and bolted to the cast-iron caps; diagonal pile bracing secures the alignment of the girders and upper end of piers. On top of the longitudinal girders, thirty-six cast-iron bases are fitted, eighteen on each side of the dock. These are fitted between the pairs of piers and form the supports for the hydraulic cylinders which pass down through them, resting on the flange at their upper ends.

There are thirty-six cylinders, 16 feet 11½ inches long, 31½ inches diameter inside, and 5 inches thick. The neck-bush and stuffing-box is bolted on top and extends above the base casting. It is finished to 30 inches diameter in the neck, 38 inches long, and is 5 inches thick. The rams were cast on end in one piece, 20 feet 7½ inches long, metal 2 inches thick, and are finished to 30 inches diameter. The castings to carry the rope sheaves are bolted directly on top of the rams. The shafts for the sheaves are of steel, 8 inches diameter, with a bearing on each side. The rope sheaves are 6 feet 4 inches diameter on the pitch line, and are grooved for eight 6-inch steel hawsers. The traverse of the rams is 15 feet for the greatest lift, the dock platform moving 30 feet. Upright standards are built on each side of the rams, of steel plates and angles, having a continuous steel girder connecting their tops. These uprights carry the guides for the heads of the rams. The back ends of the lifting ropes are anchored in the base-plate castings under the cylinders. The load on each rope with the full pressure on the rams would be 20 tons, and each has been tested with a load of 80 tons.

The platform consists of thirty-six steel cross girders, spaced 12 feet apart, 65 feet 6 inches long, 6 feet 4 inches deep at center, 34 inches deep at ends; one longitudinal continuous girder on each side, 6 feet 4 inches deep, to which all the lifting ropes are attached; one central longitudinal girder, built as an intercostal, 6 feet 4 inches deep, and two intermediate girders, 40 inches deep, built as intercostal girders. The keel blocks are arranged above the central girder, and the bilge blocks slide on the cross-girders. The wood platform is built on a framework between the girders. There are seventy-two locking-beams, thirty-six on each side, fitted on the longitudinal fixed girders, one

above each foundation pier, that are slid out by a hydraulic ram under the side girders of the platform, and upon which it rests when up.

The power for operating the dock is obtained from a pair of vertical engines, 12 inches diameter of cylinder and 16 inches stroke, geared 6 to 1, and operating four single-acting plunger-pumps, $3\frac{3}{4}$ inches diameter of plunger and 36-inch stroke, worked by disk cranks on geared shaft. A small accumulator is used to regulate the speed of the engines, and also to adjust the pressure, load being added as the dock lifts and becomes heavier. The valves of each lifting-ram of the dock are all operated together from a revolving shaft, extending all round the dock, and worked by a small engine in the pump-house, the speed of which determines the speed at which the dock will rise. The valves are fixed on the rams and rise with them, the inlet and outlet pipes working in stuffing-boxes. The inlet and outlet valves are worked by a floating lever working on a pin between the valves. When the lever is in the horizontal position both valves are shut. The end of the lever is attached to a nut, which works on a vertical screw the full length of the ram, and which is turned by the revolving shaft. When the screws start to move to lift the dock the ends of the levers all move up and open the inlet valves; the rams begin to rise, carrying the valve-box and other end of the lever up with them; but as long as the end of the lever attached to the nut is screwed up as fast as the ram rises the inlet valve remains open, but if one or more rams be lightly loaded and tends to go faster its quicker motion closes the inlet valve, and they are thus made self-adjusting. The consequence is that the motion of the rams is perfectly uniform, either in raising or lowering, the platform being at all times a perfect plane, irrespective of how the load may be disposed.

The dock was built from designs by G. W. Dickie, manager of the Union Iron Works.

INCLINED PLANES.

Inclined planes have been used for the transportation of boats, either in caissons afloat or upon cars or cradles dry, for many years. Frequently the configuration of the ground makes them desirable constructions, as they may follow the natural slope of the surface, thus permitting cheap construction.

The inclined plane at Meaux, France, was constructed to connect the river Marne with the Canal de l'Ourcq. It is about forty miles from Paris, and enables boats to pass from the river to the canal or from the canal to the river, saving a dètour to Paris, by river or canal, where the two are joined, and which generally consumes from two to three days. The slope of the incline is one twenty-fifth, and the total height to be overcome, including the summit, which adds 5 feet to the height, is about 45 feet. The boats, loaded, weigh about 70 tons, and are transported, dry, upon a car weighing 35 tons, making a total of 105 tons. It is operated by a turbine of 45 horse-power, the water to drive the turbine being taken from the upper pool of the river near the incline. A movable dam of the Desfontaine type, with a lock having a lift of about five feet, is located in the river, just above the inclined plane. The refuse water from the turbine flows into the lower pool of the river. The time of transit of a loaded boat is about forty-five minutes. The car bearing the boat is supported upon two trucks of four wheels each, the wheels being provided with double treads and an intermediate flange. In making the transit up or down the incline the wheels of the two trucks follow each other upon the rails, but run upon

different treads, and the boat and car are transported parallel to the inclination of the track. At the lower end of the incline, and the short incline from the summit into the canal where the boat is placed upon or taken off the car, the inclination of the track is increased to one-tenth and the arrangement of double treads permits the wheels of the truck which is in advance in the ascent or descent to pass upon another track, the rails of which are placed alongside the rails of these portions of the incline and at a distance from them about the thickness of the middle flange of the wheels. These additional rails are raised sufficiently above the rails of the incline to elevate the front end of the car and cause it to descend in a horizontal position into the water at both ends of the incline, and enable the boat to float off or on the car easily and without unnecessary strains.

The incline of the Blackhill Monkton Canal, Scotland, was constructed to relieve the double flight of locks near it, which were found insufficient to accommodate the traffic. The supply of water in the upper level of the canal being limited, and as the greatest quantity of water was taken from the upper level for the lockage of empty boats, because of their smaller displacement, the inclined plane was made to transport empty boats only, and its dimensions were regulated accordingly. All the loaded boats passed through the locks. The car which conveyed the light boat afloat was a trough of forged iron 71 feet long and 14 feet 6 inches wide, mounted upon ten pairs of wheels in such a manner as to remain horizontal during transit. The weight of caisson, car, water, and empty boat is about 80 tons. The inclination of the track was one-tenth, and the height overcome about 100 feet. The traffic in the canal having become reduced, and the water in the upper level being sufficient for all the boats passing, the use of the inclined plane has been for the present abandoned.

PROJECTS.

The Board has carefully considered the project of Major Handbury for locks and canals which can no doubt be made to meet every demand of commerce, and which has the advantage of keeping the boat in its proper element; but its construction involves so great an expenditure of money, and probably of time, that the Board can not favor its adoption. Major Handbury estimates that it will cost $3,754,355, but the Board believes this will have to be materially increased. One of the principal difficulties and elements of expense in this project is the improvement of the river at Ten Mile Rapids and vicinity, the cost of which must, the Board fears, be largely in excess of the estimate. Another difficulty is the water supply of the summit level of the canal for passing The Dalles, which Major Handbury proposed to furnish by constructing a feeder from the river above Celilo Falls, a distance of about 7½ miles. The amount of water necessary for the summit level may be considerably reduced by the use of hydraulic vertical lifts at the ends of the canal, similar to those described, and their use would probably also materially diminish the cost of the necessary excavation, as the site for the canal terminates at both ends upon almost vertical basaltic bluffs; but, even with this modification, which will not do away with the necessity for the feeder unless the summit is supplied by pumps from the river, the Board does not consider this project the best method of overcoming the obstructions to navigation in this locality.

Major Jones proposed two inclined boat railways, and submitted a car of special device, designed to carry the boat dry in a horizontal posi-

tion during transit. The steepest grade proposed by him is one-tenth, which is the same as that used upon the Blackhill incline, already described, and the incline on the Morris and Essex canal, near Phillipsburg, Pa. The boats upon the latter are also transported dry. The inclined plane of the Chesapeake and Ohio Canal, at Georgetown, D. C., where the boats are transported in a caisson filled with water, the total weight of which is 390 tons, has an inclination of one-twelfth; and that of the Oberland Canal, at Elbing, Germany, has a varying grade from one-twelfth to one-twenty-fourth. The boats upon this latter are mounted upon the car dry, and when loaded are about 70 tons in weight, the same as those transported upon the Morris and Essex incline. Both the inclines of the Morris and Essex Canal, and of the Oberland Canal, have an arrangement similar to the one at Meaux, for taking boats out of the water and delivering them into the water in a horizontal position. Major Jones calculates the weight of the boat and car for his inclines to be about 900 tons, or more than double the heaviest load carried upon either of the inclines mentioned.

By request of the Board, Major Jones has submitted a second project for a track and car, with an estimate for a boat railway connecting the sites of the two inclined boat railways.

The Board is decidedly of the opinion that this method is preferable to placing the boat back into the water to make the passage of the Ten Mile Rapids and then to remove it a second time from the water during a transit over the obstructed portion of the river. The use of this connecting railway, which is about 9 miles long, requires the construction of a car different in character from that originally proposed by Major Jones, and recognizing this fact he has submitted the design for another car which is better suited for the longer transit.

PROJECT FOR BOAT RAILWAY CONNECTING BIG EDDY WITH THE RIVER ABOVE CELILO FALLS, BY MAJOR W. A. JONES.

This railway is 45,100 feet long, and is composed of six double lines of 60 pound rails, which are supplemented by six additional rails on the curves, making six triple lines of rails for these portions. The maximum grade of the track is 1 per cent., and the maximum curve 2 degrees. The car drawn by two 50-ton locomotives is a platform 165 feet long and 39 feet wide, which rests upon one hundred and twenty wheels, with broad chilled iron rims without flanges. The car is kept upon the track by two sets of guide wheels so placed that the bearing wheels will rest in every position of the car upon at least two rails. The estimated cost of this car is a little more than half of that proposed for the inclined boat railways. The railway is provided with three side tracks each 250 feet long, connected with the main track by turn-tables to permit boats in transit and going in opposite directions to pass each other.

It will be seen that the Board does not adopt either the car or track proposed by Major Jones, substituting for the latter two tracks of 90-pound rails, on the ground of simplicity and convenience. The car adopted is designed by Lieutenant Burr, and is described in his report appended.

The employment of a car suitable for this long railway precludes the use of inclines unless some arrangement is effected by which the car carrying the boat is run upon another car constructed for the incline, and which would take the boat with its car from or deliver it into the water in a horizontal position. If the car bearing the boat over the

railway is not lowered into the water with the boat, it would be necessary to change the boat from one car to another at the head of the incline, an operation of doubtful propriety and one that would consume much time. Should a second car be used, the weight to be raised or lowered would be greatly increased, and the operation would probably be slow and the necessary machinery very expensive. In addition, the site, especially at the Big Eddy or west end, where the greatest height is to be overcome, is not adapted for an inclined plane without a large amount of excavation, as the road terminates upon a nearly vertical bluff of rock. The Board therefore favors the application of the vertical lift, which seems to fulfill to a greater degree all the conditions required.

The lifts at Anderton, Les Fontinettes, and La Louvière are applied to canals, and transfer boats afloat in caissons of water, which involves elevating or lowering a great weight, due to the water alone. They are also double, the weight of one caisson to a considerable degree balancing the other. In the problem before it, the Board believes that a single hydraulic lift at each end of the railway is sufficient for the present project, as at some future time a second lift could be constructed at each end of the railway, should they prove necessary. The single lift designed by Civil Engineer Petri is arranged to convey a caisson of water, and the floating power of the cylinders is calculated for a weight that is constant, or nearly so, and subject only to the comparatively small differences in the weight of the water carried, due to changes in the depth of the water in the caisson, which depends upon the height of the water in the upper level of the canal. There are, then, two objections to its use: (1) the expense of excavating so large a chamber or pit to receive the floats when depressed, which has already been mentioned; and (2) the lift at The Dalles is to take up the boat dry, and it may have to be operated without a boat, with only the weight of the car upon it, as when the car goes down to receive a boat; and therefore must accommodate itself to great variations of weight.

The weight elevated or lowered at La Louvière, which is the largest of the three hydraulic lifts visited by the Board, is 1,037 tons, and the caisson is 141 feet 1 inch in length and 19 feet one-fourth inch in width. This is supported upon a single press. The boats upon the Columbia River, for which the railway must provide, are 165 feet long, with 35 feet beam, and they may even be built with 45 feet beam. The weight to be elevated at The Dalles will therefore be distributed over an area more than double that over which the weight at La Louvière is distributed if the width of the platform be taken at 35 feet. This greater area over which the weight is distributed causes greater strength of structure to be required, and consequently an increase of weight. If, therefore, the central press system be used at The Dalles a greater weight due to the structure itself would have to be lifted than at La Louvière. In addition to this objection, the stability of the lift is likely to be seriously affected by the weight being distributed over so large an area.

For these reasons the Board does not recommend the adoption of the single or central press system. The length and width of the boats to be transported and the height of the lifts, 68 feet and 40 feet, seems to make it advisable that several presses should be used, arranged along the sides of the platform carrying the boat and car, in the manner illustrated by the Victoria Lifting Dock and the dock of the Union Iron Works in San Francisco.

SUMMARY.

It will be convenient here to recall the principal features of the obstructions, and to make some statements as to the plan recommended.

Between Dalles City and Celilo there are about 12 miles of interrupted navigation. At Celilo there is a fall in the river at low stage of 47 feet. About 3 miles below, the Ten Mile Rapids, one-half mile *long, occur* with a low-water slope at the rate of 7⅓ feet per mile. The *river, except* in high stages, here runs in a trough about 200 feet wide, with high vertical walls of basalt.

Below Ten Mile Rapids there is a short stretch 1,800 feet in length, in which the rate of fall is 11 feet per mile. Still lower down are The Dalles Rapids, about 1½ miles in length, with a low-water fall of 10 feet per mile. Here the river, except in high stages, when a portion escapes over the banks, runs in a trough of varying width between 125 and 350 feet, with high vertical basaltic walls.

In mean high stage of river the slope at Ten Mile Rapids is 5 feet per mile, while at The Dalles Rapids the fall becomes 20 to 40 feet per mile. The total fall from Celilo to Dalles City in low water is 81.4 feet, and in mean high water is 62.5 feet.

The rise of surface from low water to mean high water is at the head of falls 18 feet; at head of Dalles Rapids 73 feet, and at foot of Dalles Rapids 49 feet. These slopes make navigation of The Dalles Rapids impossible. The same is true with some qualification of other portions of the intermediate river.

It has been proposed to reduce excessive slopes by enlarging the channels at The Dalles and at or near the Ten Mile Rapids. While this work may be regarded as being probably within admissible limits of cost in the latter case, it is not so for The Dalles Rapids, and in both cases probable results in securing good navigation are, in the opinion of the Board, open to serious question.

The distance between The Dalles Rapids and the foot of Celilo Falls is about 6 miles. Projects heretofore proposed for passing boats assume the navigability of the intermediate river, 6 miles in length. The difficulty of navigating the intermediate river, and the uncertainty, both in regard to cost and results of an attempt to make this navigation a suitable link in a transportation route, are regarded as serious objections to both of these projects. The inconvenience of repeated operations of removing from and restoring a boat to the river, whether this is done by locks, inclined railways, or by hydraulic lifts, constitutes a further objection applicable to both projects.

The Board has therefore sought other solutions free from these objections, and in its report of December 18, 1888, it has favored a portage railway, on account of merits of cheapness and ease and quickness of establishment.

Recognizing that this project is not free from objection in that it requires trans-shipment of freight, and that while adequate for present demands it may not answer future requirements, the Board has, as directed in the act of August 11, 1888, caused to be prepared still another project, which it now recommends as a final solution of the problem.

In this project boats are taken from the river at the foot of The Dalles Rapids and are returned to the river at the head of Celilo Falls by means of hydraulic lifts, one at each terminus, and are transported over the intermediate distance on a railway, a little more than 8 miles in length.

The project includes improvement of Three Mile Rapid, which lies

about 2 miles below the lower terminus of the railway. Improvement of the rapids may be avoided by extension of the railway to a point below the rapids.

The Board prefers the alternative of improvement of the rapids as cheaper and more satisfactory.

The following-named points referring to the project deserve attention:

It avoids river improvement at Ten Mile Rapids.

The case permits close estimate of cost, which, in view of the extent and formidable character of the obstructions, is regarded as moderate.

The operation of transferring a boat from river to river is simple, and is effected in less time (namely, ninety minutes) than by any other method.

While the estimate here given is for boats of 165 feet in length, longer boats can be handled by using more presses and longer cars.

The capacity, sufficient equipment being provided, is the passage of forty boats each way in twenty-four hours. This capacity may be doubled by construction of an additional lift at each terminus, by lengthening to some extent the track turn-outs, and by addition of sufficient equipment in cars and engines. The track need not be duplicated.

The lift is an adaptation of the hydraulic dock in use for some years at the Union Iron Works in San Francisco. The processes are therefore not experimental.

The estimate of cost of the whole system, with equipment of two cars and four engines, capable of passing eight boats of 600 tons in each direction in twelve hours, including necessary buildings, and 10 per cent. for contingencies, is $2,690,356.35. Estimate for Three-Mile Rapids is $170,000, making an aggregate of $2,860,356.35. It is estimated that a further expenditure of $716,000 in buildings, cars, engines, and side-tracks will afford the maximum capacity of forty boats each way in twenty-four hours.

The annual cost of maintenance to pass sixteen boats in twelve hours is estimated to be $80,000.

A detailed description of the project will be found in the appended report of Lieut. Edward Burr, Corps of Engineers, to whom the Board intrusted the duty of formulating the scheme; a work which has been faithfully and intelligently performed.

A few points are however here mentioned.

The boats are 165 feet long, 38 feet beam, and 5 feet draught, weighing, with cargo, 600 tons. The weight of cradle is 184 tons, of car 300 tons. There are sixteen presses, eight on a side, weighing at the lower lift 374 tons. The total weight to be raised in this lift is 1,458 tons. The maximum load suspended from the center rams is 74.7 tons, and the maximum pressure 970 pounds on a square inch. The boat is kept in a horizontal position by means of the regulating device. The maximum lifts occur in low water. The highest is at Big Eddy, 68.2 feet. The speed is 4½ feet per minute.

The location of the line of railway was made under the direction of Major Jones. Some minor changes were afterwards made by the Board in the way of reducing vertical curves and gradients.

The road-bed is neither level nor rectilinear. The topography does not permit of either of these desirable conditions. The vertical curves give, for a chord of a car length, a middle ordinate not exceeding one-half inch. The horizontal curvature is limited to 2 degrees. The maximum gradient is six-tenths of 1 per cent.

There are two tracks, standard gauge, 20 feet from center to center. Rails are 90 pounds. The track is above high water except as hereinbefore mentioned.

The weight is 7 tons on a wheel.

It is seen that the solutions presented by the Board are a portage railroad in Washington, described in detail in the report of December 18, 1888, and the continuous boat railway herein described.

The first is a cheap and speedy solution, adequate, in the opinion of the Board, to meet existing requirements. The second is suited to a considerable commerce, and it is recommended as the most feasible and convenient method of passing a large commerce over these formidable obstructions without trans-shipment of cargo.

The estimated cost of the portage railroad is $431,500, and that of the continuous boat railway, including lifts, is $2,860,356.35.

All of which is respectfully submitted.

G. H. MENDELL,
Colonel, Corps of Engineers.

SAN FRANCISCO, CAL., *November* 8, 1889.

WM. P. CRAIGHILL,
Colonel, Corps of Engineers.

BALTIMORE, MD., *November* 15, 1889.

JAS. C. POST,
Major, Corps of Engineers.

LONDON, ENGLAND, *November* 27, 1889.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

LIST OF DRAWINGS ACCOMPANYING REPORT.

1. Map showing location of proposed boat railway.
2. Profile of proposed boat railway.
3. Transport car for boat railway.
4. Details of platform of transport car.
5. Details of trucks of transport car.
6. Hydraulic lift for lower terminus of boat railway.
7. Details of hydraulic terminal lifts.
8. Details of hydraulic terminal lifts.
9. Accumulator for hydraulic terminal lifts.
10. Valve-gear for hydraulic terminal lifts.
11. Pumping-engines for hydraulic terminal lifts.

REPORT OF LIEUTENANT EDWARD BURR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., November 4, 1889.

SIR: I have the honor to submit the following report upon the project for overcoming the obstructions to navigation in the Columbia River between Celilo and The Dalles, Oregon, by means of a boat railway. The project has been elaborated under your direction and in accordance with your instructions, and there are transmitted herewith plans of all the principal structures in sufficient detail to furnish a basis for working drawings and for reliable estimates.

Reports covering this locality have been previously made by other officers, and reference has been made to them for certain data. A description of the surroundings is unnecessary further than to state that the obstructions extend from above Celilo Falls to Big Eddy, below The Dalles Rapids, a distance of some nine miles in a very rugged country. The project is the transfer of boats and barges around these obstructions by means of one continuous line of railway, with terminal hydraulic lifts to overcome the differences of level.

The boats are of the usual stern-wheel river type, with flat-bottomed hulls molded towards the bow and stern and rounded at the lower corners of the midship sections. Practically, strongly built boxes of small height as compared with their length and considerable longitudinal flexibility, notwithstanding a trussing of "hog-chains." The maximum dimensions assumed for this project are, length over all, 165 feet; breadth over all, 38 feet; draught, 5 feet; and weight, loaded, 600 tons.

The main points to be considered are the road-bed, the car, and the lifts, and they will be taken up in the above order.

THE ROAD-BED.

The difference in river-level between the head of Celilo Falls and the foot of The Dalles Rapids is, at extreme low water, 81.15 feet, and at extreme high water 56.54 feet. The extreme rise at the two points is 28.29 feet and 66.6 feet, respectively. The plane of reference is 8.01 below low water on The Dalles (city) gauge. The references of extreme high and low water at the foot of The Dalles Rapids are 75.9 and 9.3, respectively, and for the head of Celilo Falls are 117.74 and 89.15, respectively.

The best location for the road-bed is found on the north, or Washington, bank of the river. The location assumed herein lies on that bank, and extends from the pool above Celilo Falls to Big Eddy, at the foot of The Dalles Rapids. Owing to the rugged character of the locality, a rectilinear alignment, or an alignment composed of rectilinear portions connected by turn-tables, is impracticable. The alignment necessarily contains curves. These curves are limited to a maximum of 2 degrees. The length between the faces of the two lifts is 43,320 feet, and the total length of the improvement is 45,000 feet. A turnout, 1,700 feet in length, is located about midway between the lifts, where the ground is favorable. The curves for this turnout are the same as for the main line. Short turnouts should be provided near each lift for shifting the locomotives around the car.

On the accompanying profile is shown the sub-grade line, 2 feet below the base of the rail. The grade line is level at each lift, the sub-grade reference being 117 at the Celilo lift, and 65 at the Big Eddy lift. The maximum gradients are 0.6 per cent., or 31.68 feet per mile. No difficulty will be experienced in hauling the assumed load over them. Different gradients are connected by vertical curves of 80,000 feet radius. On these curves the middle ordinate for a chord of 165 feet will be less than half an inch. The cars and boats have sufficient flexibility to readily accommodate themselves to this deflection.

The excavation is all in rock of a basaltic character. The cuttings are estimated with a bottom width of 45 feet and side slopes of 4 on 1. The embankments, with a top width of 38 feet, and slopes of 1 on 1. The latter should be made of the excavated material, and should be roughly laid and faced by hand. A packing of sand in the embankments would not be judicious, as they are all subject to greater or less submergence from a turbulent stream, the swell of which would, by withdrawing the sand, cause a continued settlement so long as any of it remained.

Retaining-walls of rubble masonry are provided where made necessary by the precipitous banks of the river, and also to protect from the wash of the current at extreme high water that portion of the road-bed opposite The Dalles Rapids. Stone culverts are also estimated for.

The tracks are two in number, of the standard 4 feet 8½ inches gauge, 20 feet between centers, and without elevation to the outer rails on the curves. The tops of the cross-ties are placed 2 feet above sub-grade, the interval being filled with broken stone ballast. The cross-ties are of fir timber, 8 inches by 10 inches by 10 feet, and spaced 22 inches between centers.

Every fifth tie is 30 feet long and extends across both tracks to bind them together. The rails weigh 90 pounds per yard, and both the rails and the fastenings should be of the most approved form at the time of construction.

The tracks are above extreme high water except for 12,000 feet at the lower end. For this distance they are subject, at rare intervals, to a submergence of from 0 to 10 feet. Mention has been made of a wall to protect this section of the road-bed from wash, and the ties should be weighted sufficiently to overcome their buoyancy and retain them firmly in place. This can be done by placing old rails of sufficient weight along the center of each track.

THE CAR.

It is required of the car that it shall transport with safety the loaded boat or barge and have sufficient flexibility to pass over the horizontal and vertical curves of the above line. The maximum load to be carried is estimated at 600 tons.

The proposed car is composed of a platform of plate-girders, and a system of four-wheeled trucks to carry it. The platform is 168 feet long by 38 feet wide. It is braced for lateral stiffness and its comparatively small depth gives it a small amount of vertical flexibility. The lateral flexibility to enable the car to pass around curves is obtained by the arrangement of the trucks. There are thirty-four trucks, placed in two lines of seventeen each. The two lines are 20 feet apart between centers, the trucks of each line are 10 feet between centers, and the wheels of each truck 5 feet between centers, giving a regular spacing on the rails of 5-foot intervals. In each line, the fourth truck from each end is pivoted in the usual manner, giving two pairs of trucks, 100 feet apart, which serve to guide the car on the rails. The remaining trucks have a freedom of motion laterally of sufficient amount to permit them to accommodate themselves to the alignment of the track. This freedom is obtained by pivoting the trucks about a point 8½ feet from their centers by means of radius bars, which also serve to hold the trucks to their places, longitudinally. The motion takes place upon sets of rollers interposed between the platform and the trucks. For a chord of 100 feet the middle ordinate for a 2-degree curve is 5.23 inches, and this is the maximum deflection for the center trucks. For the other trucks it is less.

The details of construction are as follows:

The car has a length over draw-bars of 169 feet, an extreme width of 38 feet, and a height, unloaded, of 5.1 feet above the rails. The platform is composed of two main longitudinal trusses, 20 feet between centers and connected at intervals of 10 feet by transverse trusses. The connecting points are immediately above the trucks. The transverse trusses are extended 9 feet outside of the main trusses as cantilevers, and the outer ends of the latter are connected by a channel-bar running the full length of the platform. The centers of the transverse trusses are connected by a third longitudinal truss, and six longitudinal beams of timber assist in supporting the hull of the boat and in transferring its weight to the transverse trusses.

The main trusses have single top and bottom cover plates, 12 inches by $\frac{9}{16}$ inch: 4 angles, 4 inches by 4 inches by ½ inch; and a web-plate 30 inches by $\frac{5}{8}$ inch, stiffened by 3 inches by 3 inches by ½ inch angles. The transverse trusses have single top and bottom cover plates, 12 inches by ½ inch: angles 4 inches by 4 inches by ½ inch; web-plate 29 inches by $\frac{5}{8}$ inch; and stiffeners 3 inches by 3 inches by ½ inch. The center longitudinal trusses have four angles 4 inches by 3 inches by $\frac{5}{8}$ inch; web-plate 28 inches by $\frac{5}{8}$ inch; and 3 inches by 3 inches by $\frac{5}{8}$ inch stiffeners. The side channel bar is 12 inches deep and weighs 100 pounds per yard. The inside longitudinal timbers are 8 inches by 16 inches, the outside are 6 inches by 12 inches, and all are supported on brackets riveted to the webs of the transverse members. The trusses are riveted together by 4 inches by 4 inches by ½ inch angles at all points of intersection, and the frame is braced by diagonal tie-rods in each rectangle. At the ends of each main

truss the web is spread sufficiently to allow of the introduction and attachment of the draw-bars.

The trucks may be of any design of sufficient strength. In the drawings is shown a truck of the iron frame, locomotive type, but these trucks prove to contain three-fifths of the weight of the car, and a further study may develop another form of equal advantages as to height and strength, and of less weight. The wheels should be of cast steel or wrought iron. The axles have 6-inch outside bearings, the greater spread of the bearings more nearly equalizing the load per wheel when the car is on a curve. Roller-bearings are shown, as they are better suited where frequent immersion in water is required, and they are reported to have given good results in railroad service. If, on fuller investigation, this proves not to be the case, a journal and box of the usual character, but of special design for retaining the oil, should be substituted. The springs are of the leaf pattern of the usual form, and extra heavy. They should yield sufficiently under the empty car to prevent the bearing being taken off the rollers when any truck passes a slight inequality in the road-bed, and still not have an excessive deflection under the full load. The rollers are of steel, between steel plates, which are attached, one to the truck bolster and the other to the under side of the platform.

The weight of the car is 300 tons, of which the trucks weigh 181 tons and the platform 119 tons. The maximum weight to be carried is 600 tons, and the total weight of the loaded car is 900 tons. The average load per truck is 27.6 tons, and per wheel is 6.9 tons. But the weight of the boat is greater for the midship portion, and the platform has not depth enough to uniformly distribute it. An assumption was therefore made upon the distribution of the boat's weight, and that it is carried locally, with resulting loads of 30.3 tons per truck and 7.6 tons per wheel, both of which are within practical limits. Provision is also made, in case of the failure of one truck, for carrying the load to the two adjoining trucks, with resulting emergency loads of 42.8 tons and 10.7 tons. But these loads will probably not be attained since the platform has sufficient rigidity to transfer a portion of the load beyond the two adjoining trucks.

The material of all rolled sections is presumed to be mild steel. The maximum strain for the greatest loading is restricted to 10,000 pounds per square inch for the platform and to smaller limits for the truck.

Two 50-ton locomotives, one on each track, will handle the load of 900 tons with ease on the grades of the line at the desired speed. Automatic air-brakes should be provided to assist in controlling the car and for emergencies.

THE LIFTS.

A lift is required at each end of the road-way, with a capacity to raise a live load of 900 tons. With a draught of boat of 5 feet and a height of car of 5.1 feet, the height to be lifted at extreme low water is 40.15 feet at the Celilo lift, and 68.2 feet at the Big Eddy lift. Vertical hydraulic lifts are proposed, and the hydraulic ship-lift now in successful operation in the ship-yard of the Union Iron Works in this city has been used as a model, such modifications being made as were called for by the differences in locality, load, and height of lift, or as were suggested by the operation of that lift. Mr. G. W. Dickie was the designer and constructor of the lift. The designs for The Dalles lifts were prepared with his assistance, and I am under many obligations for the facilities furnished by him in the office of the Union Iron Works.

The drawings transmitted herewith are for the lower or Big Eddy lift. The upper lift will be similar in all respects, with such a shortening in the lengths of the presses, rams, chains, and other vertical members as may be necessary to adapt it to the smaller height to be lifted.

The proposed lift consists of a platform or cradle supported by chains from the heads of a series of hydraulic rams placed in two rows, one on either side. The chains are so arranged over sheaves as to give the cradle a speed and movement four times that of the rams. A device for regulating the admission of the water to each press so controls the movement of the rams as to maintain them at a uniform speed and the cradle in a horizontal position notwithstanding any differences in the loads on the several rams. The presses and rams are inclosed in a riveted framework, which serves to steady the presses, to guide the rams and the cradle when in motion, to carry the regulating mechanism, and to support the cradle at the level of the track.

In the Union Iron Works ship-lift the cradle is suspended from each ram by eight steel wire cables, and the stroke of the rams is multiplied by two. But in the shops of the company is a single-cylinder hydraulic overhead crane, with a lifting capacity of 50 tons, the stroke of the ram being multiplied by four. A similar construction should therefore be practicable for a load per ram one-half more. The details of the proposed lifts are as follows:

There are sixteen rams, with a full stroke of 17 feet 3 inches. They are placed in two rows, 45 feet 11 inches between centers of rams, with the rams in each row 22 feet 6 inches between centers. Each press cylinder is 19 feet 7 inches long, 31.5 inches

interior diameter, with a 5-inch thickness of metal, and is cast in one piece weighing 19 tons. Each rests upon a base casting weighing 13.1 tons, which also carries two of the chain sheaves, and supports the vertical posts of the framework. To the top of the cylinder is bolted by external flanges a guide cylinder 3 feet 3 inches long, which is also braced to the vertical posts of the framework and to the face of the rock cut.

Each ram is 30 inches exterior diameter with a 2.5.inch thickness of metal, and is cast in one piece weighing 8.3 tons. On the upper end is bolted a top casting supporting a shaft which carries at each end two chain sheaves and a cross-head, the latter working in vertical slides bolted to the framework. The rams and the cylinders are calculated for a working pressure of 1,000 pounds per square inch, and should be tested to 2,000 pounds per square inch before erection.

The average weight suspended from each ram is 67.7 tons. This weight is carried by two $2\frac{1}{4}$-inch chains, each of which should be of 100 tons proof. The fixed ends of the chains are attached to the guide cylinder casting and the running ends to the side trusses of the cradle, three sheaves being interposed on each chain to give the desired multiplication.

The cradle is composed of two side trusses 170 feet long and 40 feet between centers They support the ends of the transverse trusses. The latter are 11 feet 3 inches between centers, are symmetrically placed with respect to the rams and support 4 stringers, one under each rail. The side trusses are formed of 4 angles 5 inches by 5 inches by $\frac{1}{2}$ inch; two cover plates at both top and bottom, 18 inches by $\frac{1}{2}$ inch; and web plate, 48 inches by $\frac{7}{16}$ inch. The cross girders are the same, except that the web is 45 inches by $\frac{7}{16}$ inch. The track stringers are formed of one cover plate top and bottom, 9 inches by $\frac{5}{8}$ inch; four angles, $2\frac{1}{2}$ inches by $2\frac{1}{2}$ inches by $\frac{5}{8}$ inch; and web plate 18 inches by $\frac{5}{8}$ inch.

The framework is composed of vertical posts connected at their centers and upper ends by horizontal struts, the whole braced longitudinally by diagonal tie rods, and laterally by inclined struts anchored to the rock in place. The vertical columns are built up of $\frac{1}{2}$-inch plates, 4 inches by 4 inches by $\frac{1}{2}$-inch angles, and 12-inch channel bars. The latticing is of $2\frac{1}{2}$ inches by $\frac{5}{8}$-inch iron, and the whole is proportioned to support the weight of the platform. The upper horizontal strut is a hollow built beam without bottom plate, and is formed of $\frac{1}{4}$-inch plates and 4 inches by 3 inches by $\frac{1}{2}$-inch angles. It is placed above the extreme position of the rams and supports the hydraulic pipes and the shafts, bearings, and valves of the regulating mechanism.

The platform is supported as follows: On each side of every ram a 12-inch rolled I-beam is placed horizontally at the necessary height. The inner end is supported by the vertical posts just mentioned. The outer end is anchored to the rock in place when the latter is high enough, otherwise it is supported by the inclined lateral struts and anchored to the rock by vertical rods. This I-beam supports a second movable I-beam, or chock, the outer end of which clamps over the lower beam for holding down. The entire system of chocks is operated together. Each chock is connected with the center arm of a double bell crank. Each of the other arms of the crank is attached to one of two rods which extend the full length of the lift. Each rod is operated by a small hydraulic ram, by means of which the line of chocks can be either moved into place or withdrawn.

The load will not be uniformly distributed to all the rams of the lift, and the ram with the smallest load would, unless controlled, rise faster or descend slower than any other. To cause all the rams, independent of their respective loads, to move at the same speed, and thus maintain the cradle horizontal and free from undue strain, is the object of the regulating mechanism.

Mr. Dickie designed for application to the Union Iron Works ship-lift a device that has given satisfaction. The principle of it is adopted for The Dalles lifts, with such modifications in details as were suggested by experience. The arrangement of the device is shown on the drawings, and is as follows:

On each side of the lift a horizontal shaft is placed in bearings on the upper horizontal strut of the frame-work. The shafts extend the length of the lift, are geared to the same engine-shaft, and at each ram by a worm-gearing to a vertical shaft. The latter has a bearing at its lower end on the guide-cylinder, and at its upper end on the valve-box casting. The bearings and gearings permit of a small vertical motion to the shaft. It is screw-threaded for a length somewhat greater than the stroke of the ram, and has upon it a nut or sleeve that is carried by the top casting of the ram. The sleeve is made in two parts, drawn together by bolts to take up any lost motion on the screw-thread. The upper end of the vertical shaft is attached to one end of a lever, which is attached at the other end to the valve-stem. The valve is of the ordinary slide pattern, with two ports, the upper in connection with the return or exhaust-pipe, and the lower with the interior of the press. The interior of the valve-box is in connection with the supply-pipe.

Power is furnished by a pair of direct-acting steam pumping engines of about 500 total horse-power. The stroke is 36 inches, the diameters of the steam and water cylinders are 26 inches and 8 inches respectively, and the piston rod, 4 inches diameter,

extends through both heads of the water cylinder. With 80 pounds average steam pressure, and thirty revolutions per minute, the pumps will furnish 162,000 cubic inches, or 700 gallons per minute under a pressure of 1,000 pounds per square inch.

Supply pipes deliver the water at all points and return pipes carry it back to the tank. Valves are so placed that any portion of the hydraulic machinery can be cut off without interference with the remainder of the system. An accumulator of small capacity is in connection with the supply pipes to receive any excess or supply any deficiency in the amount of water furnished by the pumps. It also automatically controls the speed of the pumps through a connection between the steam throttle and accumulator ram, such as to open the throttle as the ram falls or close it as the ram rises.

The operation of the pumping plant and regulating mechanism is as follows: The lift being at rest, the position of the regulating valves is as shown on the drawing, the connections between the presses and both supply and return pipes are closed, and the pumps furnish water only to supply leakages. To raise the cradle the engine of the regulating mechanism is so started as to wind the vertical screw-threaded shafts down through the sleeves on the ram-heads. The rams being at rest, the shafts are carried bodily downward, the slide-valves rise, uncovering the lower ports, water flows into the presses, and the rams move upwards, carrying the cradle 4 feet for 1 foot. This continues so long as the speed of the rams is the same as the speed with which the sleeves are wound upward on the shafts. If the speed of the rams is less than this regulated speed, the shafts are carried farther down, and the ports opened more fully. If the speed of the rams is greater, the shafts are carried upward, and the ports are partly closed. Should the load on any ram be less than on any other, the water will seek that press more freely, the ram will rise faster than the others and than the regulated speed, and will carry the shaft upward, partly or wholly closing the valve, which will be opened again when that particular ram is again in unison with the others. Similarly for an overloaded ram, the valve will be opened more fully.

The entire operation is automatic outside of the engine of the regulating mechanism, the direction and speed of which is so regulated as to give the desired direction and speed to the lift. When the engine is started for raising the lift, the valves open and water is drawn off from the accumulator. The ram of the accumulator falls and the steam-throttle of the pumps is opened until an equilibrium is established and water supplied in the quantity called for by the speed of the regulating mechanism. The entire operation is under the control of the regulating engine, of course within the limit of the capacity of the pumps.

The cradle is raised slightly above the track level and the regulating engine is stopped. The chocks are thrown in position beneath the cradle by operating the proper rams, and the cradle is gently lowered upon them by reversing the regulating engine.

To lower the cradle it is first raised sufficiently to clear the chocks, which are then withdrawn. The engine is reversed, winding the vertical shafts up through the sleeves. The valves are carried down, connections are made between the two ports, the water escapes from the presses back to the tank and the rams descend under control as in rising. The operation is similar to that of raising the cradle, except that the pumps take no part in it, and the limit of the speed is fixed by the ability of the water to escape through the valves and pipes. Practically the speed in lowering is considerably greater than in raising.

The cradle and all the framed portions of the lift are of mild steel and calculated for a maximum strain of 10,000 pounds per square inch. Provision is made in the side trusses for carrying the load to the adjoining rams in case any one press is disabled. The weight of the cradle is 184 tons. The weight of the car is 300 tons, and of the boat is 600 tons. Total weight suspended from the chains, 1,084 tons, and average weight per ram, 67.75 tons. The weight of each ram and its attachments is 23.4 tons. The weights of car and cradle are uniform, but that of the boat is not. The same assumption on the distribution of its weight as was made in the calculations for the car, gives as the maximum load supended from the center rams, 79.7 tons. The maximum total pressure on these rams is then four times the maximum suspended load, 79.7 tons, with an addition of 23.4 tons, the weight of the ram and fixtures. The total pressure is therefore 342.2 tons, and the pressure per square inch is 970 pounds. The speed proposed for the cradle is 4.5 feet per minute, corresponding to a speed of 1.12 feet per minute for the rams.

At any stage of the river all the portions of the lifts for operating at that stage will be above the water, with the exception of the lower bearings of the vertical regulating shafts and portions of the rams, and of the supply pipes leading to the presses. The lower lift will be totally submerged only at extreme high water, a stage of short duration and very rare occurrence. The engine and boiler houses will be conveniently located and above extreme high water.

Each of the lifts is placed in a chamber excavated for it in the rock. A channel of 60 feet bottom width leads from the river to the lift chamber. Estimates are made for a masonry pier 12 feet by 6 feet, horizontal dimensions, to support each ram, and

also for masonry linings for the vertical faces of the lifts. When the excavation for the lift chambers is made, the rock may prove of such good character as to obviate the necessity for this masonry.

AUXILIARY APPLIANCES.

Shops, round-houses, storage sheds for cars, and other permanent buildings should be located near the center of the line. All parts of the system should be connected by telegraphic or telephonic communication. A small amount of ordinary rolling-stock should be supplied.

The traffic capacity of the system is limited by the capacity of the lower lift. That capacity can be reached without any proportionally great increase over the proposed first cost of the system, but can not be exceeded without the construction of additional lifts. The estimated time required at extreme low water to raise one boat and lower another is as follows:

	Minutes.
For boat to enter lift chamber and make fast	5
For raising cradle to level of track	15
For hauling car from lift and substituting another car	5
For lowering cradle and for boat to leave chamber	10
Total for one complete maneuver	35

With an allowance of thirty-five minutes to raise one boat and lower another, the maximum capacity of the lift at extreme low-water is twenty boats each way in twelve hours, and forty boats each way in twenty-four hours; the latter a maximum tonnage of 24,000 tons in each direction. To run the line to full capacity will require six cars and twelve locomotives and a turn-out at each lift for passing cars, in addition to the central turn-out. With two lifts at each terminus the capacity can be doubled without any change in the railway other than a lengthening of the turn-outs sufficient to pass two cars at once, trains being run in two sections. The time required in passing the obstruction may be estimated as follows, for extreme low-water:

	Minutes.
To enter lower lift chamber and make fast	5
To raise cradle to level of track	15
To haul off lift, over the railway, and on upper lift	60
To lower cradle of upper lift, and for boat to leave chamber	10
Total	90

As the river rises the maximum capacity of the line increases and the time for passing the obstructions decreases. To work the line to its full capacity increases the time of passage, owing to the delay at turn-outs and at the lifts in awaiting turn.

With the opening of the railway it is proposed to furnish two cars, four locomotives, and a central turn-out. This will give one car for service, with a second in reserve for use in case of accident, and will also give two cars and their motive power for occasional use. A single car will have a maximum capacity of four boats each way in twelve hours, and two cars a maximum capacity of eight boats, or 4,800 tons, each way in twelve hours.

Estimated cost of operation to pass eight boats each way in twelve hours:

Superintendence:		
One superintendent, at $250 per month	$250.00	
One clerk, at $100 per month	100.00	
	350.00	
Total, two men for 12 months		$4,200.00
Operating lifts:		
Two engineers, at $4 per day	8.00	
Four firemen, at $2.50 per day	10.00	
Four lift-tenders, at $2.50 per day	10.00	
	28.00	
Total, ten men for 365 days		10,220.00
Operating railway:		
Four locomotive engineers, at $5 per day	20.00	
Four locomotive firemen, at $2.50 per day	10.00	
Four trainmen, at $2.50 per day	10.00	
	40.00	
Total, twelve men for 365 days		14,600.00

Maintenance of road-bed:		
One foreman, at $75 per month	$75.00	
Five laborers, at $50 per month	250.00	
	325.00	
Total, six men for 12 months		$3,900.00
Maintenance of plant:		
One machinist at $5 per day	5.00	
Two helpers, at $2.50 per day	5.00	
One blacksmith, at $4 per day	4.00	
One blacksmith's helper, at $2.50 per day	2.50	
	16.50	
Total, five men for 310 days		5,115.00
Fuel, 12 tons bituminous coal per day, at $8	96.00	
Total for one year		35,040.00
Supplies, incidentals, etc		6,925.00
Total for one year		80,000.00

To double this capacity with the same equipment by running twenty-four hours per day would pass sixteen boats each way per day, at an estimated cost per year of $150,000. To run at full capacity, passing forty boats each way in twenty-four hours, is estimated to cost $275,000 per annum.

ESTIMATE OF COST.

Right of way:		
250 acres, at $20		$5,000.00
Railway:		
467,358 cubic yards rock excavation, at $1.50	$701,037.00	
580,430 cubic yards special embankment, at 50 cents	290,215.00	
12,850 cubic yards rubble retaining-walls, at $9	115,650.00	
4,700 cubic yards rubble culverts, at $9	42,300.00	
109,854 cubic yards broken stone ballast, at $1	109,854.00	
40,000 cross-ties 8 inches by 10 inches by 10 feet, at 60 cents	24,000.00	
10,000 cross-ties 8 inches by 10 inches by 30 feet, at $1.80	18,000.00	
2,880 tons 90-pound steel rails, at $50	144,000.00	
One-twelfth of above for fastenings	12,000.00	
480 tons old rails, at $20	9,600.00	
18.1 miles single track, laying same at $750	13,575.00	
Total for railway		1,480,231.00
Celilo lift:		
36,890 cubic yards rock excavation in entrance, at $1.50	55,335.00	
8,522 cubic yards rock excavation in chamber, at $1.50	12,783.00	
886 cubic yards rubble masonry, at $9	7,974.00	
802 tons cast-iron in lift and accumulator, at $160	128,320.00	
461 tons mild steel in lift, at $200	92,200.00	
Pumps and all regulating and operating machinery	25,000.00	
Boilers	10,000.00	
Boiler and engine houses	6,000.00	
Total for Celilo lift		337,612.00
Big Eddy lift:		
4,555 cubic yards rock excavation in entrance, at $1.50	6,832.50	
26,760 cubic yards rock excavation in chamber, at $1.50	40,140.00	
1,547 cubic yards rubble masonry, at $9	13,923.00	
965 tons cast-iron in lift and accumulator, at $160	154,400.00	
525 tons mild steel in lift, at $200	105,000.00	
Pumps and all regulating and operating machinery	25,000.00	
Boilers	10,000.00	
Boiler and engine houses	6,000.00	
Total for Big Eddy lift		361,295.50

Transport car:		
17,000 pounds brass, at 30 cents		$5,100.00
22,000 pounds cast-steel, at 25 cents		5,500.00
202,000 pounds mild steel, at 10 cents		20,200.00
174,000 pounds wrought-iron, at 8 cents		13,920.00
155,000 pounds cast-iron, at 6 cents		9,300.00
7,500 feet, B. M., fir timber, at 4 cents		300.00
Air-brakes		4,000.00
Total for one car	58,320.00	
Two cars, at $58,320		$116,640.00
Locomotives:		
Four locomotives, at $15,000		60,000.00
Buildings:		
Car sheds, round-house, shops, office, quarters, etc		75,000.00
Tools and incidentals		10,000.00
Total for boat railway		2,445,778.50
Engineering and contingencies, 10 per cent		244,577.85
Improvement of Three Mile Rapids:		
42,500 cubic yards rock excavation, at $4		170,000.00
Aggregate		2,860,356.35

This estimate in all cases is for materials delivered on the site, and for constructions erected and completed ready for operation.

In conclusion, I have to acknowledge the efficient assistance of Mr. Otto Von Geldern, assistant engineer, and Messrs. John Parkins and Noel Marriotte in the preparation of the drawings and estimates presented herewith.

The drawings have been made in duplicate, and owing to the shortness of the time for preparation are perhaps not as full and complete as possible. The following drawings are transmitted herewith:

1. Map showing location of proposed boat railway.
2. Profile of proposed boat railway.
3. Transport car for boat railway.
4. Details of platform of transport car.
5. Details of trucks of transport car.
6. Hydraulic lift for lower terminus of boat railway.
7. Details of hydraulic terminal lifts.
8. Details of hydraulic terminal lifts.
9. Accumulator for hydraulic terminal lifts.
10. Valve-gear for hydraulic terminal lifts.
11. Pumping engines for hydraulic terminal lifts.

Very respectfully, your obedient servant,

EDW. BURR,
First Lieut., Corps of Engineers.

Col. G. H. MENDELL,
Corps of Engineers, U. S. A.,
President of the Board of Engineers on The Dalles Obstructions.

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*Omitted; printed in House Ex. Doc. No. 64, Fifty-first Congress, first session.

U U 2.

CONSTRUCTION OF CANAL AT THE CASCADES, COLUMBIA RIVER, OREGON.

The general scope of the improvement which it is desired to effect at the Cascades of the Columbia River includes a reach of about 4½ miles, where the river rushes through a narrow gorge in the Cascade Mountains. The fall in the distance is about 45 feet at high water and 36 feet at low water. The principal obstruction to navigation occurs at the upper end of the reach, known as Upper Cascades. The project for the improvement contemplates that the river should be improved below the Upper Cascades by removing bowlders and projecting points in the bed and banks, so as to give good, navigable water from its lowest up to a 20-foot stage. The fall at the Upper Cascades is to be overcome by digging a canal of 3,000 feet in length across the neck of a low, projecting spur, around which the river is forced at the entrance to the gorge and placing in this a lock and other suitable structures, which would permit of the passage of boats up to a 20-foot stage of water in the river, this lock and canal to be so arranged that, should the future necessities of commerce so demand, additional structures may be added which will permit of navigation at much higher stages.

The first part of this project, that of improving the river below the foot of the Upper Cascades, is essentially finished.

The difference of level between the head and foot of the canal, as now established, is 15 feet at high water and 24 feet at low water, and the difference in height between high and low water at the foot is 54 feet, and at the head 45 feet. The plan on which the future work in the canal, with its lock and accessories, is to be prosecuted, has for its object to make this portion of the river available for navigation to a stage up to 20 feet at the earliest possible moment, with the funds that are from time to time appropriated for the purpose.

At the commencement of the present fiscal year there was available for the prosecution of the work $80,512.33. At that time the lock pit was filled with water, but the river, which had had an unusually small June rise, had receded below the bulkhead and preparations were at once made for clearing the pit of water. This was completed July 4, and on the 5th active work was resumed and continued until the end of November, when it was again discontinued on account of unfavorable weather and a scarcity of funds. From that date until the end of the year outside work has been confined to taking care of the public property.

The available balance on hand this June 30 is $7,653.95.

The progress during the year is represented by results as follows: The excavation of 6,038 cubic yards of bed-rock and 1,853 cubic yards of gravel and bowlders. More than one half of the bed-rock required to be removed by picks and gads without the use of powder, for fear of loosening the foundation on which the masonry work is to rest. This was attended with considerable increase in the expense of the excavation; the making and putting in place of 1,636 cubic yards of concrete, in which there was used 2,000 barrels of imported cement. This concrete was rather rich in cement and made and placed with great care. It covered the bed-rock on which the lower gate, the lower guard gate, and the lower miter sill masonry are to rest. This bed-rock, as has been explained in previous reports, is a conglomerate of rocks and rounded pebbles of igneous origin held together by a matrix of hardened volcanic mud which exfoliates on being exposed to the air.

To secure an adherence between this and the concrete or masonry that rests upon it, it must be covered immediately after exposure. Especial care was taken with this work. All seams and pockets of soft material that were met with were followed up and carefully cleaned and filled with the concrete.

The four pivot stones for the two sets of lower gates were placed in their proper positions on this concrete.

The construction of the tail-bay walls was commenced and considerable progress made. The north wall was completed to the coping for a distance of 278 feet, and the south wall for a distance of 288 feet. Each of these is 28 feet high. The amount of wall built during the year contains 5,934 cubic yards. The body of these walls is large rubble carefully laid dry. The front face is coursed quarry-faced ashlar laid in cement mortar. These stones were cut during previous years from the basalt bowlders found while excavating the lock pit. Three qualities of stone were cut during the year: granite for miter sills; quoin and culvert stones; basalt for sill, culvert, and face stones. There were cut 5,496 cubic feet of granite, 6,124 cubic feet of dimension basalt, and 2,118 cubic feet face basalt. The granite was obtained from near Spokane Falls, Wash. At the end of last fiscal year 14,538.79 cubic feet dimension granite were due on the contract with Frederick J. Carrel, which expired on that day. This amount was purchased from him at the contract price without loss or inconvenience to the Government, and the last stones delivered February 19, 1890. The basalt was obtained from bowlders found in the Government grounds at the lock. There is now sufficient cut stone on hand to lay the sills and build the walls of the lower gates to a height of eight feet, and enough uncut to raise these to their coping courses.

During the year 335 cubic yards of basalt stone were quarried from bowlders found on the Government ground. Of this 108 were dimension stones for the lower-gate masonry, the remainder, 227 cubic yards, were rubble-stones.

A No. 5, Gates's rock-crusher, with revolving screen, was purchased and set in operation. This is preparatory to the large amount of concrete that must be provided for in the immediate future of this work.

For furtber details of the operations of the year attention is respectfully invited to the annual report of Lieut. Edward Burr, Corps of Engineers, U. S. A., which is herewith submitted.

Lieutenant Burr has been in local charge of the work during the entire year, with the exception of a short absence on duty elsewhere during the months of August, September, October, and November, 1889.

It is not contemplated to resume active operations on the work until additional funds are made available for its prosecution. After that time it is expected to push the construction of the lower lock-gate and guard gate masonry as rapidly as possible, and, if the amount available will justify, enter into contract for the granite necessary for the upper lock-gate masonry and commence its construction.

It is estimated that during the fiscal year ending June 30, 1892, $900,000 can be profitably expended in the prosecution of this work.

The Cascades of the Columbia are in the collection district of Willamette. The nearest port of entry is Portland, Oregon, 65 miles distant by river. The nearest lighthouse and works of defense are at the mouth of the Columbia River, 150 miles distant. The amount of revenue collected at Portland for the year ending June 30, 1890, is $534,015.89.

Appropriations.

June 14, 1876	$90,000	July 5, 1884	$150,000
June 18, 1878	150,000	August 6, 1886	187,500
March 3, 1879	100,000	August 11, 1888	300,000
June 14, 1880	100,000		
March 3, 1881	100,000	Total	1,442,500
August 2, 1882	265,000		

Money statement.

July 1, 1889, amount available	$80,512.33
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	72,858.38
July 1, 1890, balance available	7,653.95
Amount appropriated by act of September 19, 1890	435,000.00
Amount available for fiscal year ending June 30, 1891	442,653.95
Amount (estimated) required for completion of existing project	1,115,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	900,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

REPORT OF LIEUTENANT EDWARD BURR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cascade Locks, Oregon, June 30, 1890.

SIR: I have the honor to make the following report of operations for "Improving Columbia River at the Cascades, Oregon," for the year ending June 30, 1890.

The summer freshet of 1889 was an exceptionally small rise and of unusually short duration. The pumping out of the lock-pit was in progress at the beginning of the year and was completed on July 4. Work was resumed on July 5, and continued until November 30, when all active operations were suspended owing to the exhaustion of funds. Office work has been continued during the entire year, but since November 30, 1889, no outside work has been done other than that necessary for the care and protection of plant and property. During suspension of operations some caving and washing of the gravel slopes of the lock-pit was caused by the heavy snows and rains of the winter and by the rising water of the 1890 freshet, but the means taken for the protection of these slopes kept the damage within small limits.

The freshet of 1890 reached its highest stage on May 14 and since that date has been steadily falling. Pumping out the lock-pit can probably be commenced by the first of August. Considerable advantage would result to the work if funds were available at that time, so that operations could be resumed and advantage taken of the dry weather of the summer and early fall to push the cutting of stone and the laying of masonry, both of which are seriously interfered with by the inclement weather of the winter.

The work of the year past was in continuation of and under the same project as that of the preceding year. It was done by hired labor, and had for its object the construction of the canal walls of the lower entrance as far as the lower bulkhead and the construction of the masonry of the lower guard and lock gates. All operations were necessary or incidental to the above.

The construction of the canal-walls was resumed when the lock-pit was pumped out and continued until all that portion of them between the lower bulkhead and the lock masonry was completed to the coping course. Early in August, as soon as preparations could be made, the cleaning of the foundations and the construction of the masonry of the lower gates was commenced and continued until funds were exhausted. The excavation carried on during the year was in preparing the foundations of the different walls and in extending the canal walls to the bulkhead. Cutting stone for the lower-gate masonry was under way during the whole working season, and a sufficient quantity was cut to lay the sills and build the walls to a height of eight feet. The contract for dimension granite for this masonry was completed during the year, and a quantity of dimension basalt of large size was quarried from bowlders. Following are the details of the year's operations.

EXCAVATION.

Of the excavation for the year, about one-half was in extending the canal-walls and the remainder in cleaning the foundations of the lower-gate masonry. It all

required care, and more than half was the removal of the bed-rock with picks and gads, without the use of powder. Its increased cost over previous excavations is thus accounted for. The total material excavated was 7,891 cubic yards, including 6,038 cubic yards of bed-rock and 1,853 cubic yards of gravel and bowlders. Of this material 3,256 cubic yards were used as filling behind the canal-walls as they were built. Four thousand six hundred and thirty-five cubic yards were wasted on the outside of the protection-wall in grading the canal grounds.

The cost of excavating was $11,895.50. From this is deducted a credit of $1,628.00 for material dumped as canal-wall backing, leaving $10,267.50 as the cost of excavating, or $1.313 per cubic yard. The proportionate part of engineering, superintendence, repairs, and incidentals was $1,431.42, making the total cost for the year $11,698.92, and the cost per cubic yard, $1.483.

CANAL WALLS.

The approved project calls for dry-stone masonry in these walls. The body of the walls is large rubble, carefully laid, and the face is of coursed quarry-faced ashlar. The face stone has been very roughly cut, and where laid dry it did not give a satisfactory result.

In the walls of the lower entrance the face has been laid in cement and mortar, not only to get better results in the setting of the stone, but also to prevent the swell in this part of the canal from affecting the gravel backing by working through the open dry-stone wall. A much more satisfactory wall has been secured by this change, with an increased cost only for the cement and sand used in the mortar. This comes to about 12.5 cents per cubic yard of wall, or less than 2 per cent. of the cost of the wall.

The north wall was completed to the coping for a length of 278 feet and the south wall for a length of 288 feet. Total length of wall 566, height 28 feet. The amount of wall built during the year was 5,934.3 cubic yards, of which 972.4 cubic yards were of face stone in cement mortar and 4,961.9 cubic yards were of dry-stone rubble. Three thousand two hundred and fifty-six cubic yards of excavated gravel and bed-rock were placed behind the walls for backing. The work was done by two traveling derricks, each of which averaged 5.02 cubic yards of wall per hour. The cost of walls was as follows:

	Total cost.	Cost per cubic yard.
For face stone	$10,112.02	$1.704
For rubble stone	9,184.62	1.548
For cement and sand	748.62	.126
For supplies, tools, pumping, etc	3,435.00	.579
For labor	9,468.32	1.595
Total for field work	32,948.58	5.552
For engineering, repairs, etc	4,818.47	.812
Total for masonry	37,767.05	6.364
For backing	1,628.00	.....
Total for walls	39,395.05	.....

MASONRY OF LOWER GATES.

This masonry supports the lower lock-gate, lower guard-gate, and the power-house It also contains the discharge culverts of the lock and the supply and waste culverts for the turbines. The mass of the masonry is of concrete. The walls are faced with basalt, and the miter-sills, hollow and recess quoins, and valve settings are of granite. The thickness of the masonry on the floor of the lock is only sufficient to thoroughly protect it. The water pressure under the sills (should there be any) is to be resisted by wedged bolts carried into the bed-rock below, experiments having proved that such bolts, when properly set, have the necessary holding power.

The work of the year on this masonry amounted to little more than clearing off the bed-rock to receive it and in leveling up with concrete the foundation thus prepared. The local bed-rock, though amply able to carry the masonry pressures, is of such a variable and friable nature that much difficulty is experienced in securing a clean and firm surface upon which to lay concrete so as to obtain a joint between the bed-rock and the masonry sufficiently tight to prevent the leakage of water under pressure. It is necessary to cover the cleaned surface immediately in order to prevent the crumbling of the bed-rock which follows exposure to the air.

Especial care was taken with this work under the sills of the two lower gates.

Seams and pockets of soft material were followed as far as possible and thoroughly cleaned. One seam, following a small stream of water, was found under the site of the sill of the guard-gate. It was followed as far as practical (to a depth of 14 feet below the sill), cleaned out, filled with concrete, and the flow of water satisfactorily controlled. Most of the concrete work was of this nature, requiring the use of a rich mixture and of much neat cement and mortar.

The materials used were Portland cement, sand, and broken stone, and the mixing was done by hand. Two brands of cement were used, English (K. B. and S.) and German (Alsen).

The sand was obtained from a pit on the property of the Oregon Railway and Navigation Company, and just across their tracks from the canal grounds. It is coarse, contains much gravel and small cobbles, and requires washing, but is of much better quality than any other natural sand accessible to the work. With proper facilities for washing not only can the sand be economically used, but also the gravel and cobbles.

The broken stone was obtained from quarried bowlders.

This method is expensive and unduly increased the cost of the concrete. A quarry is an absolute necessity for economical construction of concrete, and while admitting of cheaper concrete it would leave the better bowlder stone for face work. In using the broken stone the dust and finer particles were screened out. I believe better results would be obtained by using the stone as it comes from the crusher. This crusher dust, or fine screenings, when employed as sand, gives better results than any natural sand to be found in this locality, and if allowed to go in with the rest of the broken stone would obviate the use of a part of the poorer pit sand. For setting stone these fine crusher screenings appear to be of unusual value.

The amount of concrete laid was 1,636 cubic yards, containing 2,000 barrels of Portland cement, an average of 0.82 cubic yards to the barrel. The cost of the work was as follows:

	Total cost.	Cost per cubic yard.
For cement	$8,461.69	$5.172
For sand	468.84	0.287
For stone	3,087.81	1.887
For tools, supplies, pumping, etc	1,762.11	1.077
For labor	3,148.22	1.924
Total for field work	16,928.67	10.347
For engineering, repairs, etc	2,566.72	1.569
Total	19,495.39	11.916

In connection with the concrete, the laying of the cut-stone portions of the masonry was commenced, but only four stones, the four pivot stones for two sets of gates, were placed; these are of granite, 6 feet square, and cost in place $898.65.

STONE CUTTING.

The cutting was on the stone for the lower-gate masonry; and three qualities of stone were cut, viz: Granite sill, quoin, and culvert stone; basalt sill and culvert stone; basalt face stone. The granite is roughly pean hammered, and the basalt is roughly punched, except on the meeting faces, where a finer finish is given. The basalt is nearly as hard to cut as the granite, and the difference in cost is mainly due to the cost of the rough stone and the quality of the cutting. The details of the work for the year are as follows:

	Granite.	Dimension basalt.	Face basalt.	Total.
Stone cut (cubic feet)	5,496.2	1,123.9	2,118.0	13,738.1
Cutting on above (square feet)	9,135.3	11,529.0	4,203.0	24,867.3
Stone-cutters' labor (hours)	6,493	6,573	1,593	14,659.0
Average cut per hour per man (square feet)	1.41	1.76	2.70	.....
Average cut per hour per man (cubic feet)	0.85	0.93	1.33	.....
Cost for cutting (per square foot)	$0.584	$0.470	$0.312	.....
Cost for cutting (per cubic foot)	$0.973	$0.884	$0.619	.....
Cost for stone (do)	$1.452	$0.369	$0.190	.....
Cost for engineering, repairs, etc (do)	$0.175	$0.091	$0.058	.....
Total cost for cut stone (do)	$2.600	$1.344	$0.867	.....
Total cost of cut stone	$14,292.00	$8,228.33	$1,836.85	$24,357.18

QUARRYING STONE.

The quarry work for the year was on bowlders on the canal grounds, for the purpose of obtaining dimension stone for the lower-gate masonry. The stone wanted was mainly of large size and difficult to obtain from bowlders on account of their irregular splitting. Three hundred and thirty-five cubic yards of stone were quarried at a total cost of $1,667.82; of this, 108 cubic yards were dimension stone, and cost $9.081 per cubic yard, and 227 cubic yards were rubble, and cost $3.027 per cubic yard.

The contract for granite dimension stone was completed by the delivery of 14,538.79 cubic feet of stone. The total amount received under this contract was 26,783.39 cubic feet.

MISCELLANEOUS.

A Gates rock-crusher, No. 5, with revolving screen, was purchased during the year and used for crushing stone for concrete. Power is furnished by the engine used to run the 12-inch centrifugal pump while pumping out the lock-pit. To allow of its use for either of these purposes the pump was moved up the channel to a point opposite the position of the crusher. No other important changes or addition to the working plant were made during the year, but the usual running repairs were made to both plant and buildings.

The usual office records were kept. The preparation of the plans of the work has been continued during the year. The detailed drawings of the masonry for the three sets of gates have been completed, and the working drawings for the stone-work of this masonry are well advanced. One draughtman has been engaged upon this work during the entire year. The general and detailed plans for the gates have also been in preparation during part of the year and some progress has been made with them.

Tests of sand, cement, and concrete were made. Those made with the crusher screenings show more conclusively than before that they give better results than any available natural sand. The holding power of fox-wedged bolts when set in the local bed-rock was also tried, and it was found that such bolts, when properly placed and cemented, can be depended upon for use in the miter-sills.

METEOROLOGICAL.

The river continued unusually low during the first half of the year, and on January 7, 1890, during the freeze-up, it had fallen to 68.1 on gauge No. 2, a level lower by 2 feet than any previous record. The winter was an unusually severe one in this locality. The snow-fall during December and January was about 12 feet, and the rainfall was very heavy at times. For the three days ending February 3, 1890, the precipitation was 15.79 inches, and for the seven days ending on that date it was 22.91 inches. A meteorological and gauge summary is transmitted herewith.

Very respectfully, your obedient servant,

EDW. BURR,
First Lieut. of Engineers.

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. Army.

Table giving the meteorological and gauge summaries for the year 1889–'90.

Months.	Rainfall.	Days on which rain or snow fell.	Average temperature at 12 m.	Highest readings of gauges.		Lowest reading of gauges.	
				Head of canal.	Foot of canal.	Head of canal.	Foot of canal.
1889.	*Inches.*						
July	.....	.....	81.3	106.1	87.4	103.5	83.8
August	1.000	3	73.03	103.8	84.4	100.5	78.5
September	4.950	8	68.7	100.6	78.5	97.3	73.8
October	6.515	15	64.77	98.8	75.8	97.4	73.9
November	6.800	15	50.66	98.2	75.0	96.2	72.6
December	8.460	11	37.00	96.5	72.8	94.6	70.6
1890.							
January	14.42	14	27.00	96.2	72.6	94.0	68.1
February	22.28	16	35.30	105.2	86.9	95.6	71.6
March	7.10	15	47.9	104.2	84.1	95.3	70.8
April	2.81	7	60.00	110.6	93.8	102.2	81.1
May	0.75	7	69.3	124.8	111.3	111.8	95.5
June	6.54	14	69.5	120.6	106.8	114.6	99.4
Total	81.625	125	57.03⅝	.....	.....	.....	.....

Highest reading at head of canal during the year	124.8
Highest reading at foot of canal during the year	111.3
Lowest reading at head of canal during the year	94.0
Lowest reading at foot of canal during the year	68.1

NOTE.—Reading of adopted low water at head of canal is 96.0. Reading of adopted low water at foot of canal is 72.0.

U U 3.

IMPROVEMENT OF COLUMBIA AND LOWER WILLAMETTE RIVERS, BELOW PORTLAND, OREGON.

The object of this improvement is to make and maintain a navigable channel from the city of Portland, Oregon, to the sea, having a low-water depth of 20 feet. There is included in the reach 12 miles of the Willamette River and 98 miles of the Columbia, measured along the deep-water channel. Before the commencement of the improvement, the low-water depth of channel at some of the shoalest places was between 9 and 15 feet. During last season a depth of 20 feet was attained.

The original project under which this improvement is now carried on was adopted in 1877, but has been extended and modified somewhat since that time. It contemplates that a navigable low-water channel, having a depth of 20 feet, shall be maintained by means of permanent constructions which shall protect the banks, contract the water-way, direct the currents, and control the amount of water that shall pass through sloughs having a detrimental influence upon the main channel. While these constructions are being put in place, and until their influence is fully developed, the dredging of shoal places to give temporary relief will be resorted to. The amount expended since the adoption of the present project in 1877 is $541,600.50.

This work was in charge of Maj. W. A. Jones, Corps of Engineers, from the beginning of the year until November 1, 1889.

WORK DONE DURING FISCAL YEAR ENDING JUNE 30, 1890.

At the beginning of the year the available balance of the appropriation was so small that it was deemed advisable to hold it for expenditure in giving temporary relief to navigation over such bars and shoal places as might prove troublesome to navigation during the low-water season.

The month of July was spent in marking surveys, marking the ranges of cuts to be dredged, and preparing the dredging plant for operations. On the 24th of the month, the Osgood dredge was taken to St. Helens, but on account of delays occasioned by the breakage of machinery and other mishaps of various character, it did not get fairly to work until about the middle of August. From this time until October 5, its work was continuous, but progress slow, owing to the unsatisfactory condition of the machinery, parts of which are old and much worn. On this date, just as the cut on which the dredge was at work was being finished, the steam-ship *Willamette*, belonging to the Oregon Improvement Company, collided with the dredge and damaged it to such an extent that it was necessary to withdraw for repairs. The cost of these repairs were paid by the company. During the time that this dredge was at work at St. Helens Bar, about 16,000 cubic yards of sand were removed, resulting in a navigable channel with a depth of 20 feet at extreme low water.

The tug *Lincoln* acted as tender in this dredge until September 15. After that date the snag-boat *Willamette* was used in this capacity. At intervals when this boat was not employed dumping scows, she dragged a harrow along the line of the cut for the purpose of stirring up the sand so that it might be washed away by the current.

The damage to the dredge being repaired on the 29th of October, it was taken to Walker's Island, and on the 31st commenced dredging the channel across thebar that obstructs navigation in that locality. Work was continued here until December 21 when it became necessary, by reason of inclement weather, to suspend operations and take the plant to the moorings. During this time about 17,000 cubic yards of sand were removed, which resulted in a good navigable channel over this bar of 20 feet at extreme low water.

The chain-bucket dredge, belonging to the city of Portland, having been again placed at the disposal of the engineer in charge for the purpose of dredging in the bars below the city, was set to work on Postoffice Bar in the Willamette River, August 12. It worked in that locality from this date to October 30, excavating in this time about 61,000 cubic yards of sand, resulting in a good navigable channel having 18½ feet at extreme low water of river and tide, or 22 feet at a low-water high tide.

After completing the work marked out at Postoffice Bar, the city dredge was taken to Martin's Island, on the Columbia River, and set to work on the bar in that locality. Between October 30 and December 21, it excavated 37,600 cubic yards of sand, giving a good navigable channel of 20 feet depth at extreme low water.

At the close of operations this dredge was put in order for laying up in ordinary and returned to the city. It was attended by the snag-boat *Willamette* until September 15, after that date by the tug *Lincoln*.

The experience of the season with these two dredges fully demonstrates the fact that for work in sand and coarse gravel where the material has simply to be dumped into scows alongside the serial-dipper class running on a continuous chain is far superior in economy and efficiency to the single dipper. If rocks and timber are imbedded in the material to be removed, then the chain dipper dredge is at a great disadvantage.

At the close of the season's work on these bars it was practicable to take vessels loaded to a draught of 20 feet from Portland to the sea, and by going over the bars in extreme high tides a draught of 22 feet could be permitted.

In the latter part of January the Willamette River began its usual winter rise, reaching at Portland the highest point that we have authentic record of February 5. On that date the Government gauge at the foot of Stark street registered 28.7 feet, the zero of this gauge being at extreme low water.

The remarkable high waters of the Willamette, as observed at Portland, are on record as follows:

	Feet.
Flood of 1861–'62	25.1
February 7, 1887	23.6
February 5, 1890	28.7

The highest recorded backwater from the Columbia River is that of June 24, 1876, when it reached 28.2 feet.

On February 5, 1890, while the water at Stark street stood at 28.7 feet, it was 26.2 feet at the Government mooring at North Portland, about 1½ miles below. This extraordinary fall of 2½ feet can be ac-

counted for by the fact that the water was held back in the narrow portion of the river in front of the city by the two bridges and the docks that line both banks of the river along this reach. During the flood much damage was done to these docks and considerable erosion took place in the bed of the river at the railroad bridge. From the testimony of the residents along the river above Portland, it appears that this flood was not as high in the upper reaches as some others that have occurred within their recollection. To this time no opportunity has offered for determining this fact instrumentally. The encroachments made upon the natural water-way by the docks and bridges in the city of Portland would readily account for a higher stage of water always at that place than formerly during floods. Some current observations roughly taken under my personal supervision near St. John showed that during the height of the flood the discharge of the Willamette River was not far from 400,000 cubic feet per second.

A remarkable fact connected with this flood is the rapidity with which it passed off. On the 5th of February it was the highest known; on the 1st of March the gauge registered 0.30.

Thus passing from the highest to almost the lowest known stages of water in a period of twenty-three days, this flood brought down to the lower reach of the river an enormous quantity of sedimentary matter. The sudden fall of the water left this in the river-bed without any opportunity for the current to cut well-defined channels through it, as it would have done had the fall been less rapid and the Columbia River remained low. It is quite possible that the effect of this may be felt during the low-water period of next season, and considerable dredging may have to be done to give temporary relief.

During this flood a log boom lying just above the moorings of the Government fleet, lying in ordinary at North Portland, broke and let loose a large number of logs which came down upon the fleet, tore it from its moorings, and all went floating down the river. Four boats of the Union Pacific and one other that happened to be near by gave chase, and soon overhauling the fleet tied the greater part of the boats to the bank. In the course of a few days the boats were brought back to the moorings by our own tow-boats without serious damage having been done.

There being considerable uncertainty in regard to the location of the channel in the lower reach of the Columbia, best adapted to deep-draught vessels, and it being desirable to study both the Willamette and the Columbia from Portland to the sea with the view to adapting them to the increased depth of water over the Columbia River bar, brought about by the construction of the jetty, authority was received from the Chief of Engineers to make a resurvey of a portion of the lower reach of the Columbia, where there are wide stretches with many shifting sand-bars that have not been surveyed since 1867–'68. A party was organized for this purpose and placed in the field on the 1st of May. It has not yet completed its labors.

The work that is yet to be done on the present project for improving these rivers to a depth of twenty feet will necessarily form a part of any other that may be proposed for obtaining a greater depth. It can therefore be proceeded with to the benefit of commerce as rapidly as funds may be provided.

It is recommended that the sum of $200,000 be appropriated for carrying on this work during the fiscal year ending June 30, 1892.

APPROPRIATIONS.

Act June 23, 1866 (Lower Willamette)	$15,000
Act March 2, 1867	30,000
Act July 25, (allotted)	21,000
Act April 10, 1869 (allotted)	13,365
Act July 11, 1870	31,000
Act June 10, 1872	50,000
	160,365
Act March 3, 1873 (Lower Willamette and Columbia from Portland to the sea)	20,000
Act June 23, 1874	20,000
Act March 3, 1875	20,000
Act August 14, 1876	20,000
Act June 18, 1878	30,000
Act March 3, 1879	45,000
	155,000
Act June 14, 1880 (Lower Willamette and Columbia from Portland to the sea, including bar at the mouth of the Columbia)	45,000
Act March 3, 1881	45,000
Act August 2, 1882	100,000
	190,000
Act July 5, 1884 (Columbia and Lower Willamette below Portland, Oregon)	100,000
August 5, 1886	75,000
	175,000
Act August 11, 1888 (Columbia and Lower Willamette rivers below Portland)	100,000
Total	780,365

This work is in the collection district of Willamette and Oregon. The ports of entry are Portland and Astoria, Oregon. The nearest light-house and works of defense are at the mouth of the Columbia River.

The commercial statistics for the Columbia and Willamette Rivers below Portland being essentially the same as for the mouth of the Columbia River, reference is invited to the tables given in my report on the works at that point.

Money statement.

July 1, 1889, amount available	$37,623.34	
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	29,843.13	
July 1, 1890, balance available	7,780.21	
Amount appropriated by act of September 19, 1890	100,000.00	
Amount available for fiscal year ending June 30, 1891	107,780.21	
Amount that can be profitably expended in fiscal year ending June 30, 1892		200,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

U U 4.

IMPROVEMENT OF WILLAMETTE RIVER ABOVE PORTLAND, OREGON.

The project for this improvement was adopted in 1878 and extended in later years. It consisted in snagging operations, bar scraping and

sluicing contraction of water-way over shoals, and rock removal. Its object is to give easy navigation for light-draught vessels from Portland to Eugene City, Oregon, and in 12 miles of tributaries, making in all a distance of 184 miles. The mouth of the Yamhill River, 40 miles above Portland, was the head of an inconvenient low-water navigation in a draught of 2½ feet, only 1 foot could be carried above.

During the low water of last season, which was the lowest known, a channel 26 inches in depth was maintained to Independence, 82 miles above Portland. At one time there was but 23 inches on the lower miter-sill of the locks at Oregon City.

The total amount appropriated for this work since the present project was adopted is $113,000. All of this has been expended, excepting $200.21.

This work was in charge of Maj. W. A. Jones, Corps of Engineers, from the beginning of the fiscal year until November 1, 1889. At the commencement of the fiscal year there was a balance of $4,036.48 available for this work.

During July, August, and September, the snag boat *Corvallis*, with a small crew, worked on the river as high up as Buena Vista, 90 miles above Portland. The bar at this point stopped further progress up the river. From here down a least channel depth of 26 inches was obtained. A depth of 34 inches was obtained to Salem. Work was done by this boat at the following bars: Candianis, Christman's, Fairfield, Mathemey's, Lone Tree, McCloskey's, Rice's, and Eda. During the season 138 snags were removed.

The snag-boat *Willamette* worked during the first eight days of July in this river between Portland and the mouth of the Yamhill River. Five snags were removed, some sluicing done at Yamhill Bar, and a portion of the old dam at Clackamas Rapids blasted away.

At the end of September, all the available funds having been exhausted, work was discontinued and the *Corvallis* lay up in ordinary.

This stream is of such a character that a certain amount of work will be required every season to keep it in anything like a reasonable condition for boating. The channels and bars are constantly changing and exposing new rocks, snags, and other obstructions at every change. A small force with suitable boat and outfit can be very profitably employed during all low stages of the water in closing sloughs, building wing-dams, scraping bars, and removing snags and rocks.

The boat belonging to this appropriation is no longer fit for service. Her hull, which was constructed in 1877, is rotten and ready to go to pieces. It has seen a great deal of hard service in the last thirteen years. That which has caused the most rapid decay, however, is lying idle during several months of each year. A part of the machinery of the boat is now worthless, and other parts may be used to advantage in a new hull. To obtain a new boat and outfit for this work, making use of such parts of the old as may yet be serviceable, would cost at least $10,000. These could be profitably employed during eight months of the year. For running expenses and maintenance a yearly sum of $12,000 should be provided.

ESTIMATES FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

It is estimated that $22,000 can be profitably expended upon this work during the fiscal year ending June 30, 1892.

APPROPRIATIONS.

Act March 3, 1871	$16,000
Act March 3, 1873	3,000
Act June 23, 1874	7,500
Act March 3, 1875	25,000
Act August 14, 1876	20,000
Act August 18, 1878	20,000
Act March 3, 1879	12,000
Act June 14, 1880	12,000
Act March 3, 1881	15,000
Act August 2, 1882	5,000
Act July 5, 1884	10,000
Act July 5, 1886	10,000
Act August 14, 1888	29,000
Total	184,500

Money statement.

July 1, 1889, amount available	$4,036.48
July 1 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	3,836.27
July 1, 1890, balance available	200.21
Amount appropriated by act of September 19, 1890	11,000.00
Amount available for fiscal year ending June 30, 1891	11,200.21
Amount that can be profitably expended in fiscal year ending June 30, 1892	22,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

This river is in the collection district of Willamette and Oregon. The ports of entry are Portland and Astoria, Oregon. The nearest light-house and works of defense are at the mouth of the Columbia River.

The president of the Willamette Transportation and Locks Company furnishes the information that during the year ending June 30, 1890, the total tonnage through the locks at Oregon City was 45,130 tons. The previous year this tonnage was 54,040 tons. The decrease is due to the high water of last February which injured the locks and rendered them unfit for service during several weeks. These figures represent nearly the whole of the tonnage of the river. There is some commerce above Oregon City that does not pass through the locks. Its amount is small.

U U 5.

IMPROVEMENT OF COWLITZ RIVER, WASHINGTON.

The project for the improvement of this river contemplates a removal of the sand-bars, snags, overhanging trees, rocks, and other obstructions in the channel from its mouth to a distance of about 50 miles above. Work has been done to Toledo, about 30 miles above the mouth. The ruling navigable depth prior to improvement was 14 inches over this reach. It is now 36 inches. The total amount that has been appropriated for the improvement of this river is $11,000. This amount was all expended prior to the commencement of the present fiscal year. No other funds having been made available, no work was done during the year.

This work was in charge of Maj. W. A. Jones, Corps of Engineers, until November 1, 1889.

It is estimated that $4,000 can be profitably expended upon the improvement of the navigation of this river in accordance with the project during the fiscal year ending June 30, 1892.

APPROPRIATIONS.

Act of—	
June 14, 1880	$2,000
March 3, 1881	1,000
August 2, 1882	1,000
July 5, 1884	2,000
August 5, 1886	2,000
August 11, 1888	3,000
Total	11,000

Money statement.

Amount appropriated by act of September 19, 1890	$8,000
Amount that can be profitably expended in fiscal year ending June 30, 1892. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	4,000

COMMERCIAL STATISTICS.

This river is in the collection district of Willamette and Oregon. The ports of entry are Portland and Astoria, Oregon. The nearest light-house and works of defense are at the mouth of the Columbia River.

Statement of Cowlitz River traffic for the year ending June 30, 1890.

(Furnished by the J. Kellogg Transportation Company.]

General merchandise	tons..	9,425
Hay	do...	2,800
Shingles	bundles..	140,520
Lumber	feet, B. M..	1,620,240
Logs	do...	100,000,000
Live stock	number..	4,820
Passengers	do...	13,845

Converting the above quantities into tons will approximate 216,500 tons.

U U 6.

GAUGING WATERS OF THE COLUMBIA RIVER, OREGON.

The object of these gaugings is to ascertain and keep a record of the fluctuations of the Columbia River, with the view to gathering information that may be useful in works of improvement on the river, and also by gauges established at various points to indicate to pilots, captains, and others interested in navigation the stage of water on crossings and places of difficult navigation.

A self-registering gauge has been in operation at Astoria, Oregon, during the entire year. Daily sheets were exhibited on a bulletin-board in that city, which exhibit to pilots and others interested in the condition of the bar at the mouth of the Columbia River the stage of

water and the degree of roughness of the bar. These are of great service to commerce.

APPROPRIATIONS.

Act of—	
August 2, 1882	$500
July 5, 1884	1,000
August 5, 1886	1,000
August 11, 1888	2,500
Total	5,000

Money statement.

July 1, 1889, amount available	$2,085.17
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	608.68
July 1, 1890, balance available	1,476.49
Amount that can be profitably expended in fiscal year ending June 30, 1892	1,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

U U 7.

PRELIMINARY EXAMINATION OF THE UPPER COLUMBIA RIVER, WASHINGTON TERRITORY, BETWEEN WALLULA AND BRITISH LINE.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, October 15, 1888.

GENERAL: Referring to Captain Young's estimate for cost of a preliminary examination of the Upper Columbia River, I have the honor to report that such examination has already been made. (See Annual Report of Chief of Engineers, 1885, page 2445.) From this it will be seen that in my judgment the locality is worthy of improvement, and I therefore recommend that a survey be made of such portion of it as may be justified by the present appropriation. In 1884 the sum of $6,000 was allotted for surveying the reach from Snake River up to and including Priest Rapids. This sum was applied by me to a detailed survey of the 11-mile obstruction at Priest Rapids and a boat reconnaissance and plane table examination of 50 miles beyond, including the obstructions at Cabinet Rapids. Report of this survey with extensive and detailed maps and information on a scale equal to that of The Dalles survey of 1878, were submitted in my annual report for 1886, (see Annual Report, Chief of Engineers, 1886, pages 1953–1970), including a project for improvement.

I have now to recommend that an allottment of $10,000 be made from which this survey may be extended to the completion of the work at Cabinet and Rock Island rapids and the extension beyond as far as possible into the Foster Creek Rapids above the mouth of the Okanogan River.

Very respectfully, your obedient servant,

W. A. JONES,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF THE UPPER COLUMBIA RIVER BETWEEN WALLULA AND BRITISH LINE.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, December 31, 1889.

SIR: I have the honor to submit the following report relative to a survey of the Upper Columbia River, between Wallula and British line, for which an allotment of $4,000 was made by your letters April 1 and June 4, 1889, from the funds appropriated for examinations and surveys in the river and harbor act of August 11, 1888.

The field work of this survey was done under the direction of Maj. W. A. Jones, Corps of Engineers, U. S. Army, who was relieved from duty in this district by me just as the work was finished.

The allotment not being sufficient to cover the whole distance, estimated to be about 427 miles, it has been expended on the survey of the reach between the head of Rock Island Rapids and the head of Cabinet Rapids, a distance of about 6½ miles.

Not being able to obtain funds sufficient for the complete survey of the reach, it has been thought best to obtain from time to time reliable data on which to base estimates for the improvement of the worst sections of the river, commencing at the lower portion. The allotment of $6,000 made for this survey from the appropriation for surveys in the river and harbor act of 1884 was expended on this principle in the survey of Priest Rapids, and a reconnaissance of Cabinet Rapids.

The party for the survey of Rock Island Rapids was organized in the latter part of August, and September 2, commenced actual field work. During the organization and first operations the party was in charge of Mr. F. J. Carrel. He, however, was obliged to sever his connection with the work September 9, after the first week's operation. From this time until its close at the end of October the field work was in charge of Mr. J. C. Ensign.

During the time that the survey was in progress the stage of water was, as nearly as could be ascertained, 4 feet above low water. The soundings shown on the maps herewith are reduced to the low-water stage. The slope measurements shown are for the stage 4 feet above low water. From these it appears that the river within the reach surveyed has a fall at that stage of 23 feet. Over Rock Island Rapids, within a distance of 1½ miles, the fall is 12.5 feet.

A discharge measurement taken at the foot of this rapid gives 58,000 cubic feet per second as the quantity of water flowing in the river at this time.

At the close of the field work an attempt was made to establish connection by levels between Cabinet Rapids and Priest Rapids, 45 miles below. The party had gone but a short distance with this work when cold and snowy weather came on and caused it to be abandoned.

During the spring of 1888 a small steamer, length 125 feet, beam 22 feet, draught 26 inches, was built at Pasco, Wash. In July of that year she made a trip from thence to the mouth of the Okinakane River, distance about 200 miles, passing over Priest, Cabinet, Rock Island, and other rapids in this reach. At two other times during the summer this boat passed up over Cabinet and Rock Island rapids. These trips were made at a stage about 12 feet above low water. This boat makes frequent trips from the head of Rock Island to near the mouth of the Okinakane.

I inclose herewith a copy of Major Jones's instructions to Mr. Carrel, who was at first in charge of this party in the field, Mr. J. C. Ensign's

report on the survey, a tracing from a map made of Rock Island Rapids, scale 1 inch to 200 feet, and a tracing of the map made of the Columbia River between the head of Rock Island Rapids and the head of Cabinet Rapids, scale 1 inch to 400 feet.

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

LETTER FROM MAJOR W. A. JONES, CORPS OF ENGINEERS, TO MR. F. J. CARREL.

AUGUST 22, 1889.

SIR: You are instructed to take charge of the survey party assembled at Ellensburgh, Wash., and proceed with it to Rock Island Rapids, on the Columbia River, and there commence a survey of the river downwards. This survey is to be the same in character as that you made at Priest Rapids. It will cover the reach that includes Rock Island and Cabinet rapids, and thereafter if there is time a line of levels to Priest Rapids, with such other work in the way of soundings and slope at high and low water as may be done while leveling is going on.

Instead of float-current measurements near Rock Island Rapids for discharge, precise measurements for slope in a selected reach will be made for the determination of the discharge by means of Kutter formula. The following instructions cover this matter:

Select a straight reach free from large whirls and eddies with shore a uniform line (on both sides preferable). Select a section where bottom is uniform (sand or gravel), and set up a line at right angles for taking plenty of soundings for section. Take these soundings with extreme care, forward and back several times, reading the guage carefully all the time. At the same time this is being done take the slope measurements. Select two points above and below equidistant from the section and conveniently distant so that the whole slope between them will be the slope *at the section.*

There must be no eddies near these points and the banks near must be regular. Drive a stake at each point as far out from the shore as a man can wade and observe the hook gauge to be placed upon it, and handle the targets. Now place a hook gauge on the bottom of a target rod at each post, and so place these rods on the post as to make it easy for a man to keep the point of the hook set at the surface of the water, and at the same time control the movements of the target. Then set up level at some intermediate point (preferably near the section line) on shore and observe for difference of level. At least fifty readings forward and back should be taken so that the method of least squares may be used in determining the error.

Party can keep the field until November 10, on or before which date it must proceed in boats to Pasco, and there disband. Timely notice should be furnished me of the probable date of arrival at Pasco so I may have rail transportation at hand for the party.

At such time as you may find it necessary to leave the work, turn over entire charge of the party to Mr. J. C. Ensign, together with these instructions.

Very respectfully,

W. A. JONES,
Major of Engineers.

Mr. F. J. CARREL,
Ellensburgh, Wash.

REPORT OF MR. J. C. ENSIGN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, December 24, 1889.

SIR: I have the honor to submit the following report concerning survey of Rock Island Rapids, Columbia River, Washington:

This work was under direction of Maj. W. A. Jones.

The party, consisting of two instrument observers, four boatmen, two rod-men, one Chinese cook, were engaged in Portland. Boatman Machelle and I left Portland August 23; arrived at Pasco 6 p. m. same day. We were here for the purpose of getting the boats in order and shipping them.

We left for Ellensburgh August 25; arrived there same day in evening; made arrangements to have boats, freight, etc., hauled to Rock Island.

Mr. Carrel arrived in Ellensburgh August 26, p. m.; rest of party from Portland arrived August 27, 11.45 p. m., having been delayed one day by railroad. Upon arrival of the party Mr. Carrel took charge, and we proceeded August 28 to cross the mountain to Rock Island, arriving August 30; went in camp on the right bank of the river, below the foot of the island, having been three days on the road. Three teams were employed in making the transfer, one four-horse and two double. There are some very heavy grades on this road, and freighting over it is hard and slow. The work of making camp and preparing for field work, such as repairing boats, etc., consumed two days' time. Boatman Jennings' took sick and left the party September 5, leaving us with three boatmen, which was crew enough, the boats being small. Actual field work was begun September 2 and continued until October 26. Mr. Carrel left the party September 9, having placed the work in my charge. The system under which this survey was made was inaugurated by Mr. Carrel, and is the same as that of the survey he made of Priest Rapids in 1885, about 50 miles below Rock Island.

Careful triangulation was made to locate principal signals. Topography was taken with a plane table and by cross sections with level. Two water gauges were established, one above and one below the Rapids, from which daily readings were taken and recorded. The river stage during the survey was good, at one time getting down to 4 feet above low water. Soundings were taken with a line and located by observers stationed on shore with transits. Sextants were sometimes used on the boat. In leveling for water-surface slopes, great care was observed. A continuous line of levels was run and checked, establishing numerous bench marks on both sides of the river and on the island, admitting of all the levels being taken the same day, which was done. The water being on a stand, good results were obtained.

A cross section for discharge measurement was made below the Rapids; numerous floats were drifted across the section, were carefully timed, and were located with transits. This completed the survey of Rock Islands Rapids, October 12. Survey was then continued down stream about 5 miles to the head of Cabinet Rapids, under another system, that of locating signals by a transit line and sketching topography. October 19, camp was moved down stream about 3 miles to a point nearer the work. Survey was finished November 26, having had a season of good weather, excepting a few rainy days, some strong winds, and a short smoky spell. The members of the party are entitled to credit for good conduct and faithful duty; the boatmen being skilled and careful. October 27, Observer Harer, with two boatmen with the boats, started to Pasco, under the following instructions: To run a line of levels, beginning at the lower end of this work, to Priest Rapids, connecting with the bench marks established there by Mr. Carrel in 1885. Shortly after starting, heavy rains and snow drove them into shelter, and after waiting two days they gave up the work and proceeded on to Pasco, arriving November 2, and in Portland November 3, the rest of the party returning via Ellensburgh. Broke camp October 28, arrived in Ellensburgh October 30. For this tranfer one 4-horse team was employed, having a trail wagon. October 31, party arrived in Portland and was disbanded. The two skiff-boats used were brought from Pasco, off the U. S. E. drill-scow and shipped by rail to Ellensburgh, and were hauled across the mountain on the wagons, along with provisions, instruments, etc. They are ordinary flat-bottomed boats, about 15 feet in length, straight on the keel, are too small and not the right shape. Skiff-boats, with lots of sheer in keel, would be the proper things.

Accompanying this report are two tracings, one of Rock Island Rapids, the other showing the entire stretch covered by the survey. Also, a brief history of navigation through, from, and above Rock Island Rapids.

Very respectfully, your obedient servant,

J. C. ENSIGN,
Assistant Engineer.

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

The history of navigation through, from, and above Rock Island Rapids is confined to a stern-wheel steamer, *The City of Ellensburgh*, owned by Thomas H. Nixon, of Tacoma, Wash., and commanded by Capt. A. W. Gray. W. P. Gray was chief pilot on the first three trips.

The *Ellensburg* was built and launched at Pasco, Wash., in 1888. Her first trip was to the Okinakane River, in July, 1888, distant about 180 miles. Three days after starting she arrived at Port Eaton, about 20 miles below Cabinet Rapids. In attempting to pass Cabinet Rapids she met with a serious accident, by which her stern was knocked off. She was beached a short distance below and repaired, after which she made a safe passage, three days later arriving at Okinakane River. Since this she has made two round trips between Port Eaton and the Okinakane, returning once to Pasco. The stage of water during these trips was about 12 feet above

low water. She has since been confined to the route she now runs, from her landing above Rock Island to Casimo, near the mouth of the Okinakane, about 100 miles. In 1888, between September 10 and December 19, she made nfteen round trips. In 1889, from April 8 to October 20, forty-four round trips were made. By the kindness of Capt. A. W. Gray, I was asked to make a trip over this route on the steamer, which I did. The obstructions along the route are sunken rocks, gravel bars, and sharp, jutting points of rock. There are about twenty places along the route where improvements would be beneficial; this includes several very swift rapids. Proper boats with good power would have little trouble over this route.

Dimensions of steamer: Length, 125 feet; beam, 22 feet; depth of hold, 4 feet 6 inches; draught (light), 26 inches.

Engine: Twelve inches diameter; stroke, 3 feet. Steel boiler, 19.5 feet length, 54 inches diameter.

Very respectfully, your obedient servant,

J. C. ENSIGN,
Assistant Engineer.

REPORT AND PROJECT FROM MAJOR W. A. JONES, CORPS OF ENGINEERS, FOR IMPROVING ROCK ISLAND RAPIDS, CABINET RAPIDS, AND PRIEST RAPIDS, COLUMBIA RIVER.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minn., February 15, 1890.

The Columbia River crosses the international boundary, 26½ miles west of the boundary between Washington and Idaho Territory, and after flowing through mountainous country for a distance of 106 miles in a direction a little west of south, it enters the great plain supposed to have been occupied by an inland sea for a long period subsequent to the lava flows, which cut off the main drainage through the Cascade Mountains. Immediately upon entering this basin it trends directly to the west along the northern border of the great plain for a distance of 105 miles, when it strikes the foot of the hills of the Cascade Mountains and is turned to the south along the western confines of that plain. This is one of the two big bends of the Columbia River, and that portion of the great plain inclosed between its two arms is widely known as the Big Bend country. It is remarkable for its fertility and requires no irrigation, but is absolutely destitute of springs of running water. There is little doubt, however, but that water will be found abundantly by boring through the rock strata. Through this country the river is very new, geologically. It is still rapidly carving its way through the unstable lavas and basalts which generally form its bed. But the places where the waterway has not yet been cut out sufficiently to allow the river to pass through freely are very numerous. These are the places where navigation is now obstructed by rocks and rapids. From the point where the river debouches from the mountains westward to the Cascade Mountains they are particularly numerous. Over the reach of 105 miles between Spokane River and the mouth of the Methow River, fully 30 miles are badly obstructed by rapids and rocks.

Through this country and as far south as Priest Rapids the river flows at a level of several hundred feet below that of the plateau it incloses. Over the whole reach described and as far down as the foot of Priest Rapids, there is no flood plain. The river is still expending all its energy in cutting downwards. This, taken in connection with the fact that outside of flood stages the river carries but little sediment, would seem to indicate that the average slope of the bed was considerable.

The reach of river extending from the head of Rock Island Rapids to the foot of Priest Rapids covers a line along which the Columbia River

has cut its way through a broad spur from the Cascade Mountains. Here over a distance of 59½ miles there are three extensive obstructions:

	Miles.
Rock Island Rapids	0.4
Cabinet Rapids	2.5
Priests Rapids	10.22

ROCK ISLAND RAPIDS.

At this point the river has cut around both sides of a large island of rock. The channel, however, on each side is very much obstructed with reefs, rocks, and points sharply projecting from the shore. The result is a waterway so much restricted at all stages as to dam up the waters to such an extent that they escape over lines of very steep slope and amidst great masses of reef, rocks, and high projecting islands. A great reef is found a short distance above the head of the island which has caused extensive deposits of gravel, nearly choking the channel at low water.

Observations were only taken at a 4-foot stage. Hence we only have the slopes at that stage. It will be reasonable, however, to assume that these slopes will increase at lower stages. A slight examination of the map will show how difficult and dangerous were the boating operations carried on. One line of soundings was carried through the main rapid—a great feat. The bottom, however, occupied by the rapids remains practically unexplored. Many reefs and sunken rocks may exist besides those shown. The great reef at the foot of the island, which nearly closes the section, is very imperfectly shown.

Below the rapids the river has a tolerably uniform width of from 800 to 1,000 feet, with depths from 20 to 30 feet at the stage observed. At Rock Island the least width on the right that would be obtained after removing all obstructions would be 450 feet with depths of 20 to 25 feet. The sum of the widths on both sides of the island can be made about 800 feet at minimum sections.

The approximate discharge at a 4-foot stage was 58,000 c. f. s. But my instructions for taking discharge measurements were not carried out and the very imperfect method of maximum surface velocity by floats was used. I am also much embarrassed by not having the field-notes of the survey before me and by having an entirely insufficient length of time in which to discuss the local conditions and prepare a project.

At and above the 4-foot stage the water passes around both sides of Rock Island. Below it—although the obstructions do not show it—from what I can gather, the flow along the left bank is entirely interrupted opposite Fish Hawk Point and the whole discharge is effected through the right-hand channel. If all the rock obstructions in this channel were removed the slope would only be reduced 1:450 at a 4-foot stage, because of the extensive obstruction produced by the reefs and gravel bars just above the head of the island. This is too steep for navigation. By removing this reef the gravel bar would probably disappear and a navigable slope be reached. By leaving the large peninsula in place the whole slope becomes concentrated over a line, AB, 2,000 feet long, and is 1:220. The problem would then remain to get boats over this reach.

It is very much obstructed with islands and peninsulas, as shown, but most particularly at the lower end, where the map does not show it. About on the line PQ the section is nearly closed by a reef, extending, with broken intervals, quite across the river. Across this reef at the above-mentioned stage the slope is 1:100.

PROJECT.

It is proposed to assist boats over this reach by power applied at the upper end of the large peninsula, as shown.

It is proposed to remove the following rocks, as marked and shaded on the map in red:

	Cubic yards.		Cubic yards.
a (exposed)	98	*f* (exposed)	1,472
b (exposed)	100	*g* (exposed)	2,880
c (submerged)	2,000	*h* (exposed)	6,720
d (exposed)	31,438	*i* (exposed)	350
e (exposed)	600	*k* (exposed)	168

This will afford a passage-way over which boats can go down freely and safely. In order to assist them while going up, auxiliary power is proposed. A steam-boat can easily get over a rapid whose velocity is 8 miles per hour. I mean such boats as have to be built for service on the Upper Columbia and Snake Rivers. So it will be safe to estimate an available current to run a current-wheel on a scow, of 8 miles per hour.

When the velocities become less than that, the boat can go up without help. As the velocities increase beyond that, the quantity of power required to help her along will gradually increase. There are no data that I know of from which reliable estimates can be based for this. A practicable way of determining the power developed by the rapid, would be to anchor a steam-boat in an 8 or 10 mile current. Take all the steam from the cylinders and observe the revolutions produced per minute of the wheel, by the current. Then take her into still water, anchor her, and observe by means of an indicator the horse-power necessary to produce the same amount of revolutions per minute, as was produced by the current.

An ordinary steam-boat wheel and scow is suggested. Such a wheel would be about as follows:

Diameter	feet	15
Length	do	30
Buckets	No	20
Width of buckets	feet	1.5

The useful power developed by such a wheel in an 8 mile current would be about 50 H. P. This with suitable gearing applied to a winding drum, would afford ample power to aid a steamboat in passing up over the rapid. I have had considerable personal experience with this question of passing steamboats over rapids and can state that there will be no difficulty in steering a boat while acted upon by auxiliary power, even in the swiftest water. The location of the scow can best be determined after the rocks are removed. Here she should be securely held by anchor lines, either to the bottom or to the shore. Then lead the towline from the drum to a pulley at the point X and from thence down past an open pulley at Y to the foot of the line AB where the boat can pick it up.

The ultimate improvement of this most difficult piece of river may be effected in two ways that appear to me:

(1) Remove all obstructing rocks and reefs until something near a normal section shall have been produced.

(2) By passing boats across at Fish Hawk Point by means of a short railway with lifts worked by power developed from the river.

There is not sufficient data before me from which to estimate a normal section at the various stages. Neither is there sufficient from which to

state the quantities of rock to be removed from the various localities shown, more than approximately. Such a statement of the quantity to be handled in removing rocks at l, m, n, o, p, q, and the reef PQ, shaded in black on the chart herewith, in addition to those previously enumerated, would be in round numbers:

Cubic yards (submerged)	88,000
Cubic yards (exposed)	218,800

In large quantities such rock should be handled at an average cost of $1 per cubic yard for exposed, and $6 per cubic yard for submerged. I have done similar work for about those figures.

This would make the whole cost of improvement that would involve no future expense:

88,000 cubic yards, at $6	$528,000
218,800 cubic yards, at $1	218,800
Total	746,800

The cost of a boat railway would be:

2 hydraulic lifts, at $100,000	$200,000
Water-power plant	10,000
500 feet of track, at $100	50,000
Total	260,000

Wear and tear and maintenance per year, $20,000. The whole representing a capital outlay at 4 per cent. of $760,000.

The cost of the project for furnishing boats with auxiliary power from a permanent station would be as follows:

(1) Rock removal:		
2,000 cubic yards submerged, at $6	$12,000	
43,300 cubic yards exposed, at $1	43,300	
		55,300
(2) Auxiliary power: Anchor a scow wheel in rapids and lead a line through pulleys at X and Y and from thence down to the boat to be assisted.		
Scow and wheel, with quarters for watchman, and outfit complete	2,500	
Gearing and winding drum	500	
Tow-line	500	
Buoys, tackle, anchors, and fastenings	500	
Total for scow and power	4,000	
Blasting	55,300	
Scow power	4,000	
Contingencies	6,700	
		66,000

CABINET RAPIDS.

No measurements of rock for quantities have been made here. Available facts have been obtained from the reconnaissance made in 1886. Hence no estimates for removing rock can be presented.

For a description of this rapid see Annual Report, Chief of Engineers, 1886, page 1965, from which the following is taken:

> Cabinet Rapids are situated about 45 miles from the head of Priest Rapids. Referring to the accompanying map, which has been prepared from the plain table field map, it is seen that the chief obstruction is at the head of the rapids. At this point a mass of basaltic rock projects from the left shore nearly two-thirds across the channel of the river, deflecting the current and causing it to impinge upon the nearly vertical basaltic rocks on the right bank. This mass of rock is at its extremity much worn and channeled by the action of the water, presenting the appearance of a collection of high rock islands with narrow and winding passages between.

These passages are not channeled out to the same depth as the bed of the river; some of them are laid bare at low water. The general height of the islands, or masses of rock, is such that they stand about 12 or 15 feet above low water, and are mostly covered from 6 to 8 feet at ordinary high water. The extreme high water of 1876 just reached the tops of the highest knobs. On the right bank are rocks considerably above this height which show water-worn surfaces, proving the comparatively recent lowering of the river bed to its present level. On the left bank of the river it has formed a high-water channel running completely around the rock obstruction, which thus becomes an island at high water, having the main channel to the right, and a wide and shallow channel to the left. The total fall in the river from the top of the upper rapid to the foot of the group of islands 8,000 feet lower down-stream is at extreme low water only 10 feet, and is not greatly altered at any stage. The greatest slope is at the main rapid, and is at the rate of about 1 in 250 at low water, but is then quite short in distance. As the river rises this rapid lengthens and becomes more steep. Below the main rapids the river in rising from low water to high water of 1885 (a rise of about 22 feet) maintains a nearly uniform slope, indicating an increased obstruction below this part of the river. This is probably due to the large masses of rock on both sides of the channel of the river below. For a further rise in the river up to extreme high water of 1876 the slope increases but little.

About 4,000 feet below the main rapid the river is obstructed at low-water stages by a group of rocks on the right, a reef in mid-channel, and rocks on the left. This obstruction is not serious and can be removed at small cost. About 2,000 feet further down, or 6,000 feet from the main or upper rapid, is a group of large rock islands occupying the center of the channel, which is divided into two narrow channels fairly navigable. These islands are about 15 feet above low water, and are covered 18 to 20 feet at high water.

Below this place the river turns abruptly to the left, and is navigable without improvement, except that which is necessary at Eagle Rapids.

This rapid, owing to the precipitous character of the rocks between which it flows, becomes rapidly worse as the river approaches the higher stages, when it probably becomes impassable.

I would recommend auxiliary power as the best and quickest means of assisting boats here.

Anchor the scow at the best point in the rapids (see sketch herewith) and lead the tow-line thence through a pulley at X, and thence to the ascending boat in the eddy just below the reef. Descending boats can pass freely.

ESTIMATE OF COST.

One scow and wheel with quarters for watchman and outfit complete	$2,500
Gearing and winding drum	500
Tow-line	500
Buoys, tackle, anchors, and fastenings	500
	$4,000

From here down to Priest Rapids the distance is 45 miles over a good river.

PRIEST RAPIDS.

A description of these rapids will be found in Annual Report of the Chief of Engineers, 1886, page 1961, from which the following is taken:

A study of these maps, together with the accompanying profile of the river surface, shows that the obstruction to navigation consists of a series of rapids, seven in number. Of these, three are shown upon the detail map of the Lower Rapids, and two upon that of the Upper Rapids. The remaining two rapids are situated between these two groups, but being of little importance, are shown only on the general map. The total fall from the head of the Upper Rapid (near Station 31 L) to the foot of the Lower Rapid (near Station 1 L), a distance of 10.22 miles, is, at extreme high water, 63.50 feet, and at extreme low water, or thereabouts, 72 feet. This fall is by no means uniform, the greater part being concentrated at the Upper and Lower Rapids. Between these two groups the river is fairly good and the channel deep. The fall from the head to the foot of the Lower Rapids is 35 feet at extreme low water. This is reduced to about 20 feet at the extreme high stage, and at the moderately high water of 1885 was 26 feet.

Referring to the detail map of these three Lower Rapids, it is seen that a little above a line drawn through Stations 12 L and 12 R is the head of a long, low island, which

extends down to the Lower Rapid. The formation is basaltic; the island is in places covered with bowlders, but is mostly bare, and the exposed surface is cut and channeled in every direction by the constant action of the river at the high stages, when the island is submerged. The main body of the river flows through the channel on the left, forming a rapid opposite Station 12 L, having at low water a fall of 12 feet, which at high water is reduced to only 4 or 5 feet.

Opposite Station 9 L, water flows into the main channel through two or three chutes or channels, crossing the island from the minor channel to the right, in which the water is 8 feet higher than in the main channel.

There is no obstruction to navigation opposite Station 8 L. Here the shore on the left juts out into the channel at nearly right angles, forming a shoulder of bed-rock averaging from 2 to 6 feet high, and extending 1,400 or 1,500 feet down the river.

The channel here makes a fork or V, of which one branch, carrying the main body of water, passes to the right, cutting diagonally across the island a narrow, straight passage having vertical walls of basaltic rock 7 or 8 feet above the surface of the water, which rushes and whirls between them. This passage is colled Tumwater, and is from 60 to 70 feet deep. The other branch of the channel forms a rapid, extending from opposite Station 6 L to 7 L, and continues its course along the left bank through a channel full of rocks and bowlders, the water being about 5 or 6 feet deep at low water.

Opposite the lower end of the island, and between stations 4 and 5 L, is another rapid, which may be considered the first or lower rapid of the Priest Rapid series; for, although there is a rapid extending from the island to the right bank, near Station 4 R, the channel above this rapid has no navigable outlet save through Tumwater. There is a passage on the right of the island which is quite similar in appearance to Tumwater. The water here is from 70 to 80 feet deep, and there is very little current, but at the head of this passage is a vertical fall of about 7 or 8 feet, and in the channel above these falls there is but little depth of water, the average being from 3 to 4 feet and the bottom flat bed-rock.

It is proposed to overcome these rapids with auxiliary power, the same as at the rapids above, and also to clear out the channel-way by blasting a portion of the submerged rocks shown in red on the charts herewith. The quantities are:

	Cubic yards.
Rapid No. 1	500
Rapid No. 2	2,500
Rapid No. 3	600
Rapid No. 6	1,200
Rapid No. 7	150
	5,000 at $10 = $50,000

Place a scow-wheel in Rapid No. 1, with leading pulley at X. Cost of scow and all appurtenances, $4,000.

An analysis of the slopes shows that boats can pass Rapid No. 2 after the two large rocks in the channel are removed.

At Rapid No. 3, place a scow-wheel with leading pulley at X. Cost of scow with all appurtenances, $4,000.

No further improvement will be needed until we reach Rapid No. 6, where a scow-wheel should be placed with leading pulley at X. Cost of same, $4,000.

Summary for Priest Rapids.

5,000 cubic yards of rock, at $10	$50,000
3 scow-wheels, at $4,000	12,000
Contingencies	6,000
Total	68,000

Summary for whole reach, including Rock Island Rapids, Cabinet Rapids, and Priest Rapids.

Rock Island	$66,000
Cabinet	4,000
Priest	68,000
Whole cost for 59½ miles of river, with over 5 feet at low-water stages	138,000

Annual maintenance.

Five watchmen, at $900	$4,500
Wear and tear and maintenance of five scows and outfits, at $500	2,500
Total maintenance	7,000
The whole, with interest at 4 per cent., representing a capital outlay of	313,000
Say per mile	5,260

STEAM.

This discussion will not be complete without a statement of the cost of a steam plant for furnishing the auxiliary power.

Five 50 horse-power stationary engines, with boilers and all appurtenances complete, at $2,000	$10,000
Five engine houses and engineers' dwellings complete, at $3,000	15,000
Towlines	2,500
Buoys, tackle, etc	2,500
Gearing and winding drums	2,500
Total	32,500
Summary:	
Blasting	105,300
Power plant	32,500
Contingencies	13,200
Total	151,000
Maintenance five engineers, at $1,200	6,000
Fuel:	
Say 1 ton coal per day for 180 days per year, 180 tons, at $6	1,080
Oils and waste	60
Total	7,140
Wear and tear, say 6 per cent., on $32,500	1,950
Annual maintenance	9,090
Annual maintenance:	
Water plant	7,000
Steam plant	9,090

The project for opening the reach of river which includes Priest, Cabinet, and Rock Island Rapids to navigation by means of auxiliary water power as described is recommended.

The following maps are herewith: (1) Priest Rapids, lower end; (2) Priest Rapids, upper end; (3) Cabinet Rapids; (4) Rock Island Rapids; (5) Rock Island Rapids and River down to Cabinet Rapids; five small sheets, Priest Rapids; one small sheet, Cabinet Rapids.

Respectfully submitted.

W. A. JONES,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

APPENDIX V V.

ANNUAL REPORT OF CAPTAIN W. A. KIRKLAND, UNITED STATES NAVY, SUPERVISOR OF THE HARBOR OF NEW YORK, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

OFFICE OF THE SUPERVISOR
OF THE HARBOR OF NEW YORK,
New York, July 9, 1890.

GENERAL: In compliance with your letter of 12th February, 1890, I herewith forward the annual report of operations of this office for the fiscal year ending June 30, 1890, together with estimate of amount of appropriation that will be required for the fiscal year ending June 30, 1892.

The increase in this estimate, in the case of the *Argus*, is owing to the very numerous and extensive repairs which have to be made on her. She is a very inferior boat, and requires a constant expenditure of money to keep her at work. The estimate for two additional tugs is made in case the supplement proposed to the act, naming the waters within the jurisdiction of the supervisor, should become a law.

Very respectfully, your obedient servant,

W. A. KIRKLAND,
Captain, U. S. Navy, Supervisor.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

OFFICE OF THE SUPERVISOR
OF THE HARBOR OF NEW YORK,
New York, July 9, 1890.

GENERAL: I have the honor to submit the following report of the operations of this office for the fiscal year ending June 30, 1890; also an estimate of amount required for the fiscal year ending June 30, 1892.

The office of the supervisor of the harbor of New York was created by act of Congress approved June 29, 1888, entitled "An act to prevent obstructive and injurious deposits within the harbor and adjacent waters of New York City, by dumping or otherwise, and to punish and prevent such offenses." Sections 1, 2, 3, and 4 of this act, relating to dumping, are herewith appended.

AN ACT to prevent obstructive and injurious deposits within the harbor and adjacent waters of New York City, by dumping or otherwise, and to punish and prevent such offenses.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the placing, discharging, or depositing, by any process or in any manner, of refuse, dirt, ashes, cinders, mud, sand, dredging, sludge, acid, or any other matter of any kind, other than that flowing from streets, sewers, and pass-

ing therefrom in a liquid state, in the tidal waters of the harbor of New York, or its adjacent or tributary waters, or in those of Long Island Sound, within the limits which shall be prescribed by the supervisor of the harbor, is hereby strictly forbidden, and every such act is made a misdemeanor, and every person engaged in or who shall aid, abet, authorize, or instigate a violation of this section, shall, upon conviction, be punishable by fine or imprisonment, or both, such fine to be not less than two hundred and fifty dollars nor more than two thousand five hundred dollars, and the imprisonment to be not less than thirty days nor more than one year, either or both united, as the judge before whom conviction is obtained shall decide, one half of said fine to be paid to the person or persons giving information which shall lead to conviction of this misdemeanor.

SEC. 2. That any and every master and engineer, or person or persons acting in such capacity, respectively, on board of any boat or vessel, who shall knowingly engage in towing any scow, boat, or vessel loaded with any such prohibited matter to any point or place of deposit, or discharge in the waters of the harbor of New York, or in its adjacent, or tributary waters, or in those of Long Island Sound, or to any point or place elsewhere than within the limits defined and permitted by the supervisor of the harbor hereinafter mentioned, shall be deemed guilty of a violation of this act, and shall, upon conviction, be punishable as hereinbefore provided for offenses in violation of section one of this act, and shall also have his license revoked or suspended for a term to be fixed by the judge before whom tried and convicted.

SEC. 3. That in all cases of receiving on board of any scows or boats such forbidden matter or substance as herein described, it shall be the duty of the owner or master, or person acting in such capacity, on board of such scows or boats, before proceeding to take or tow the same to the place of deposit, to apply for and obtain from the supervisor of the harbor appointed hereunder, a permit defining the precise limits within which the discharge of such scows or boats may be made; and any deviation from such dumping or discharging place specified in such permit shall be a misdemeanor within the meaning of this act; and the master and engineer, or person or persons acting in such capacity, on board of any tow-boat towing such scows or boats, shall be equally guilty of such offense with the master or person acting in the capacity of master of the scow, and be liable to equal punishment.

SEC. 4. That all mud, dirt, sand, dredgings, and material of every kind and description whatever taken, dredged, or excavated from any slip, basin, or shoal in the harbor of New York, or the waters adjacent or tributary thereto, and placed on any boat, scow, or vessel for the purpose of being taken or towed upon the waters of the harbor of New York to a place of deposit, shall be deposited and discharged at such place or within such limits as shall be defined and specified by the supervisor of the harbor, as in the third section of this act prescribed, and not otherwise. Every person, firm, or corporation being the owner of any slip, basin, or shoal, from which such mud, dirt, sand, dredgings, and material shall be taken, dredged, or excavated, and every person, firm, or corporation in any manner engaged in the work of dredging or excavating any such slip, basin, or shoal, or of removing such mud, dirt, sand, or dredgings therefrom, shall severally be responsible for the deposit and discharge of all such mud, dirt, sand, or dredgings at such place or within such limits so defined and prescribed by said supervisor of the harbor; and for every violation of the provisions of this section the person offending shall be guilty of an offense against this act, and shall be punished by a fine equal to the sum of five dollars for every cubic yard of mud, dirt, sand, dredgings, or material not deposited or discharged as required by this section. Any boat or vessel used or employed in violating any provision of this act, shall be liable to the pecuniary penalties imposed thereby, and may be proceeded against, summarily by way of libel in any district court of the United States, having jurisdiction thereof.

* * * * * * *

Approved June 29, 1888.

This act is carefully drawn, and affords ample power to the supervisor to carry out its intent, but the "adjacent or tributary waters" are not specially named, and this omission gave rise to doubt in the mind of the judge of the district court, who dismissed a libel filed under this act, United States *vs.* Tug *Sadie*, which decision was reversed by the United States circuit court, Judge E. H. Lacombe, February 11, 1890, who says:

> The description of the waters with which the act is concerned—a description contained in the first section—seems to be drawn with great care, and sets forth comprehensively and clearly just what area is the subject of legislation. The phrase used is "in the tidal waters of the harbor of New York, or its adjacent or tributary waters, or in those of Long Island Sound." This language seems too plain to call for

construction. The bodies of water referred to are (*a*) the harbor of New York, (*b*) waters adjacent to the harbor of New York, (*c*) waters tributary to the harbor of New York, (*d*) Long Island Sound; and as to each of these bodies of water there is a restriction of the application of the act to such waters only as are tidal. As to this enumeration it is to be noted that it covers not only the harbor proper, but also waterways by which commerce reaches that harbor, and it covers *all* such waterways as are tidal. That Congress chose this language with a full appreciation of its meaning and of the geographical situation to be dealt with is plain from the reference to Long Island Sound.

In the next place it is to be noted that under the statute it is not the supervisor of the harbor who is to prohibit such dumping, etc., in the tidal waters named in the act. The act itself prohibits such dumping "within the limits which shall be prescribed" by that officer. These limits which he is to prescribe are the lines or boundaries on one side and the other of which, respectively, such material may and may not be dumped.

The decision of the district court sustaining the exception to the first cause of action is reversed and the exception overruled.

This decision of Judge E. H. Lacombe is opposed to that of the United States Attorney-General, W. H. H. Miller, who, under date of May 21, 1889, says:

The only expression in the act which would seem to give any color to the claim of jurisdiction in the waters of the Hudson River as far away as the points named is "tributary waters;" but I think it is plain from the connection that by the use of these words, Congress did not intend that the authority of this supervisor of the harbor should extend to the remote limits of the navigable waters of tributary rivers. On the contrary I am of the opinion that the term "tributary waters" must be restricted so as to cover only such parts of the river as, in a broad sense, can be regarded as connected with the harbor of New York. It can hardly have been intended, for instance, that a person designing to excavate or dredge the river 150 miles above New York should, before commencing work, apply to the harbor master of New York for a permit as provided in section 3 of the act in question.

In view of this disagreement of legal authorities, a supplement to the act, naming the adjacent and tributary waters, and more clearly specifying the water limits of the supervisor's authority, has been sent to the Department for the action of Congress.

On the 18th of October, 1889, being designated by the President of the United States, I assumed charge of the supervisor's office, relieving Capt. Robert Boyd, U. S. Navy.

The force at that time consisted of one clerk and one messenger, in the office; two deputy inspectors, in New York; one inspector, two deputies, and three boatmen, stationed at the branch office at Fort Hamilton, where the towing permits issued to the tug masters were collected, and one deputy inspector at Perth Amboy. There was no inspection of the Brooklyn, Williamsburgh, or Jersey City shores. By authority of the Secretary of War, November 8, 1889, this force was increased by three inspectors for the above-mentioned shores.

On November 9 the steamer *Argus*, constructed for this work by order of the War Department, was delivered to the supervisor, and the force was further increased by a master, engineer, and four men, as a crew for this tug, which has been constantly engaged in patrolling the harbor.

The system of collecting the permits by a small boat at Fort Hamilton was inefficient. There were no means of ascertaining where the mud-scows were dumped after passing that point, as their work was continuous through the twenty-four hours. It was decided, therefore, to purchase a vessel, under the appropriation of $60,000, act of March 2, 1889, "for the purchase or construction of a vessel," and the tug *Nimrod*, of 51 tons net, was purchased by authority of the War Department and put in commission on May 1, and, with the tug *Argus*, was stationed in the Narrows, from which position they follow the tows to

the authorized dumping-grounds and collect their permits. The inspector, deputies, and boatmen at Fort Hamilton, being no longer required, were discharged on April 30, 1890.

The system of shore inspection, which was given a thorough trial, has been found useless, as the inspectors have not been able to report any infraction of the law. It was, therefore, decided by the War Department to build two steam-launches for the purpose of patrolling the water-fronts day and night and following the tows until they were within the view of the tug stationed at the Narrows. In this way any violation of the law, within the waters of the upper and lower harbor, would be under the eyes of the force of this office, and therefore not likely to occur. These launches will be ready in July, 1890, and the inspection of the shore fronts will be done with them.

Should the limits of the authority of the supervisor of New York Harbor be fixed by law, so as to include the tidal waters of the Hudson and those of the State of New Jersey, adjacent and tributary to the said harbor, two more steam-tugs will be required in addition to those now in use.

It seems useless to trust to the inhabitants of these shores, and to the persons employed on their waters, for any reports against law-breakers, other than those of a general nature, unaccompanied with affidavits or specifications as to time and place, though this office is flooded with rumors of illegal dumping, some of which we know are utterly untrue. Even parties whose means of livelihood are injured by the alleged illegal dumping, such as oystermen and fishermen, in the bay of New York and through the kills, are unwilling to make complaints on which libels could be entered, averring that the dumpers would revenge themselves on complainants by total destruction of their oyster-beds and fishing nets. The violations of the act must, therefore, be reported by the employés of this office, and to watch such an area requires the increase of the force suggested.

There has been moved and deposited into the waters, at properly designated places, behind bulkheads and on shore about the harbor of New York, during the fiscal year ending June 30, 1890, the amount of 9,711,141 cubic yards of material, mud, city refuse, garbage, cellar dirt, ashes, acids, lime, and other matter, as per the following recapitulation:

Place of deposit.	Kind of material.	Amount.
		Cubic yards.
Mud Buoy	Mud, etc	4,092,506
Refuse Buoy	City refuse, garbage, etc	956,735
Scotland Light-ship	Mud, etc	1,839,352
Long Island Sound	do	353,418
North River	Dirt, ashes, etc., behind bulkheads and on shore for filling	647,464
East River	do	324,894
Harlem River	do	95,789
Hudson River	do	65,721
New York Bay	do	883,375
Newark Bay	do	321,166
Staten Island Sound	do	5,219
Pelham Bay	do	2,850
Shrewsbury River	do	24,160
Raritan Bay	do	650
Sheepshead Bay	do	27,104
Raritan River	do	32,445
Passaic River	do	500
Sandy Hook	do	2,434
Barren Island	Acids, dead animals, etc., on shore in store	35,359
Total		9,711,141

Permits issued 9,051

The vast quantity of material, in the form of harbor dredging, mud, and cellar dirt, which is deposited outside of the harbor, might be made use of in filling up the shoals and flats which border the Jersey shore and those around Staten Island; and it would be a cheap and ready material for the filling of such shoals as the West Bank and the Dry Romer, suitable provision for retaining it in position having been made. The former, the West Bank, now used as a quarantine, could be enlarged to meet the growing requirements of our commerce; and the Dry Romer, lying between Sandy Hook and Coney Island, could be provided with fortifications to cover the east, the swash, and the main channels to the harbor. The matter which is now dumped, when stirred up by the tides and the easterly winds, finds its way back into and deposits on the shoals and flats of the lower harbor. The creation of islands, with well defined and permanent limits on the two shoals above mentioned, will also assist materially in keeping the channels scoured by the body of water from the Hudson and the Jersey rivers. Large quantities of this material are now deposited on cars and carried out on the line of the Pennsylvania Railroad, where it is used for filling.

The disposition of the garbage of these large cities, bordering on New York Harbor, is a matter deserving serious consideration, on account of the annual increase of the material from the increased population. The subject has been referred to the mayor of New York by the chamber of commerce. There is no doubt that cremation, in crematories established along the shores in different districts, is the safest method of reducing the refuse matter; and its after use as filling would be followed by no results prejudicial to health in the regions where deposited.

The disbursements for the office of the supervisor of the harbor of New York were made by the disbursing clerk of the War Department up to April 1, 1890, on which date, by direction of the honorable Secretary of War, the supervisor was made disbursing officer.

The following is a statement to July 1, 1890, of the appropriations made for "Prevention of obstructive and injurious deposits within the harbor and adjacent waters of New York City."

Appropriation, 1888–'89, act of June 29, 1888	$30,000.00
Expended to July 1, 1890	29,957.09
Balance July 1, 1890	42.91
Appropriation, 1889–'90, act of March 2, 1889	34,070.00
Expended to July 1, 1890	22,315.22
Balance July 1, 1890	11,754.78
Outstanding liabilities, contracts, orders, etc	8,584.04
Balance after deducting liabilities	3,170.74
Appropriation, 1889–'90, act of March 2, 1889, "for the purchase or construction of a vessel"	60,000.00
Expended to July 1, 1890	36,520.00
Balance July 1, 1890	23,480.00

The following is a list of the employés in this office July 1, 1890, with date of their appointment, rating, pay, and station:

Name.	Rating.	Pay.	Appointment.	Station.
S. M. Klotz	Chief clerk	$1,500	Nov. 9, 1889	Supervisor's office.
A. Murphy	Stenographer	750	Aug. 26, 1889	Do.
A. Elliott	Messenger	540	Oct. 3, 1889	Do.
R. C. Hager	Master	1,200	Nov. 9, 1889	Steamer *Argus*.
W. R. Bailey	Engineer	1,200	Jan. 1, 1890	Do.
R. Hamilton	Fireman	720	July 1, 1890	Do.
Ed. Blake	Cook	600	Nov. 9, 1889	Do.
Wm. Halliday	First deck-hand	600	... do	Do.
A. Hoffman	Second deck-hand	360	Apr. 18, 1890	Do.
Jas. Quirk	Master	1,200	May 1, 1890	Steamer *Nimrod*.
W. A. Bloomer	Engineer	1,200	... do	Do.
Ch. Halliday	Fireman	720	... do	Do.
Geo. Parsons	Fireman's helper	480	... do	Do.
W. G. Loring	Deck-hand	600	... do	Do.
F. J. Wren	... do	600	July 1, 1890	Do.
Edward Kure	Cook	600	... do	Do.
J. G. Bolander	Superintendent of construction.	1,200	May 9, 1890	Bay Ridge, L. I. Ofeldt's Works.
F. A. Tappen	Deputy inspector	900	May 16, 1890	*Nimrod's* launch.
Robt. Walsh	Boatman	600	May 20, 1890	Do.

In addition to the above force the employment has been authorized by the Department of one deputy inspector at $900 per annum, and two licensed firemen at $720 each, for each of the two steam-launches *Active* and *Alert*, now under course of construction and to be delivered to this office in a few days.

The force at present under the supervisor of two tugs and two steam-launches is, and will be, constantly employed, both by day and night, in watching the operations of the dumping-scows in and out of the harbor, and in patrolling the water-fronts of New York, Brooklyn, and Jersey City, and the villages along the kills on the Staten Island and New Jersey shores.

The following is an estimate of appropriation required for the service of the fiscal year ending June 30, 1892, by the supervisor of the harbor of New York:

Detailed objects of expenditure and explanations.	Estimated amount that will be required for each object.	Amount appropriated for fiscal year ending June 30, 1891.
Prevention of obstructive and injurious deposits within the harbor and adjacent waters of New York City:		
For pay of inspectors, deputy inspectors, office force, and expenses of office	$20,000	$15,000
For pay of crew and maintenance of the steamer *Nimrod*	10,000	10,000
For pay of crew and maintenance of the steamer *Argus*	10,000	8,000
For pay of crew and maintenance of steam-launch *Active*	3,000	.....
For pay of crew and maintenance of steam-launch *Alert*	3,000	.....
For purchase or construction of two steam-tugs	60,000	.....
For pay of crew and maintenance of two steam-tugs to be purchased	20,000	.....
Total	126,000	33,000

Very respectfully, your obedient servant,

W. A. KIRKLAND,
Captain, U. S. Navy, Supervisor.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[To be inserted at page 3083, Part 4, Annual Report Chief of Engineers, 1890.]

ERRATA: REPORT OF THE MISSISSIPPI RIVER COMMISSION, BEING APPENDIX W W, ANNUAL REPORT CHIEF OF ENGINEERS, 1890.

Page 3084.—Under Surveys and Examinations, fourth line, for complete read completed.
Under General Service, ninth line, insert with before thirty-eight.
Page 3085.—Eleventh line, insert is before asked for.
Page 3086.—Under Second district (*b*), second line, for plan read place.
Page 3087.—Ninth line, for District read Districts.
Under Third district, second line, for Russell read Rossell; eleventh line for resulting read resulted.
Page 3088.—Under (*d*), ninth line insert still before caving.
Under A, third line, insert Ark. after Lakeport.
Page 3091.—Under A, eighth line, for timbers read timber.
Page 3092.—Under List of Appendices, C, for report read reports.
Page 3093.—Under List of plates accompanying the foregoing report, reference to the photographic plates Nos. 5 to 33, Appendix F, is omitted; also three photographic plates in Appendix I are not listed.
NOTE.—No MS. copy of this list has been received.
Page 3094.—Eleventh line, for $9\frac{1}{3}$ read $9\frac{1}{8}$.
Table, fourth column, for Quatrelle read Quatrelli.
Seventh line below table, for 1754 read 1757.
Tenth line below table, for statement read table.
Nineteenth line below table, for Maggione read Maggiore.
Twenty-first line from bottom, for Parma, Cremona read Parma-Cremona.
Nineteenth line from bottom, take out quotation marks at beginning of line.
Fifteenth line from bottom, take out quotation marks at beginning of line and complete quotation mark before arise.
Page 3095.—Tenth line below table, for rise read increase.
In General Wilson's letter, fourth line, for banks read sides.
Fifth line in same, for points read places.
Seventh line from bottom take out old.
Page 3096.—Under (1) Cairo, fifth line, for 1.0 read —1.0.
Under (3) Helena, second line, add Dec. 26, 1872, 0.00.
Page 3097.—Twenty-fourth line, insert in part after probably due.
Twenty-sixth and twenty-seventh lines, for 18 read 24.
Twenty-eighth line, for 69 read 73, and for sixty-ninths read seventy-thirds.
Page 3098.—First line, for country read century.
Eleventh line, for straight read straighter.
Seventeenth line, after stable regimen insert suited to its sediment.
Nineteenth line, after deep water insert So Bayou La Fourche, needing a high slope for stable regimen when its waters fall to the level of swamps but a few feet above gulf level, builds up its bed, necessitating high levees.
Nineteenth line, insert too after so.
Twenty-sixth line, for waters read water.
Page 3099.—9—8 lines from bottom, for subsidenee read subsidence.
Page 3103.—Twenty-first line from bottom, for charge read overcharge.
Page 3105.—Eighteenth line from bottom, for discharges read discharge.
Page 3106.—Second line after each insert river.
Sixth line, for dividing rivers read dividing the river.
Twentieth line, for main read original.
Page 3107.—Appendix C. Headline for Report for read Reports of.
Page 3112.—Appendix E, first line of text, for operation read operations.
Page 3113.—Thirteenth line, for 18 7 read 1887.
Page 3118.—First column, second line, for * substitute †.
Last line, for the north read and north.
Page 3119.—Fourteenth line in the report, for Tuttle read Turtle.
Page 3120.—Last column, eighth line, for 1881 read 1882.
Page 3123.—Section 10, tenth column, for 1 : 1.24 read 1 : 2.24.
Page 3124.—Section 35, eleventh column, for 279 00 read 279 30.
Section 40, fourth column, for 191, 433 read 191, 453.
Section 58, eleventh column, for 224 26 read 224 20.
Page 3125.—Section 85, last column, for 22,590 read 22,500.
Section 88, last column, for 22,709 read 22,700.

Page 3125.—Section 93, fifth column, for 3,442 read 3,482.
Page 3126.—Section 108, third column, for 25,206 read 25,200.
Section 108, tenth column, for 1: 1.21 read 1: 2.21.
Section 127, thirteenth column, for 16,000 read 16,900.
Page 3127.—Section 137, twelfth column, for 69 37 read 59 37.
Section 183, tenth column, for 1: 3.22 read 1: 1.32.
Page 3128.—Section 199, twelfth column, for 10 08 read 10 18.
Page 3130.—Section 35, fourth column, for 25.7 read 27.7.
Section 36, fourth column, for 27.7 read 25.7.
Page 3132.—Section 155, eighth column, for 71.6 read 81.6.
Section 156, eighth column, for 85.0 read 75.0.
Page 3133.—Section 242, fourth column, for 55.9 read 25.9.
Section 244, fifth column, for 58.7 read 53.7.
Section 246, eighth column, for 57.5 read 75.5.
Section 256, eighth column, for 27.0 read 77.0.
Section 265, seventh column, for 43.3 read 43.2.
Page 3134.—Section 306, fourth column, for 24.4 read 34.4.
Page 3135.—Section 394, sixth column, for 3,466 read 3,460.
Section 402, sixth column, for 2,270 read 2,770.
Page 3136.—Section 471, fifth column, for 100.9 read 109.9.
Section 475, seventh column, for 78.1 read 75.1.
Section 492. sixth column, for 2,268 read 2,263.
Page 3137.—Section 519, sixth column, for 2,187 read 2,189.
Page 3138—Third column, at Memphis and Chotard Ldg. insert "0.0" in each case.
Page 3139.—In table, column of lowest water, opposite White River, Natchez, and Red River Ldg. insert "0.0" in each case.
Page 3140.—In table, third line, for on read or.
Page 3142.—Eighteenth line, after doing insert during.
Page 3144.—In table, third column, opposite St. Joseph and Port Hickey insert "0."
Page 3145.—Fifth line, second column, for * substitute †.
Page 3149.—Mean velocity, Old River, Jan. 9, for 2.257 read 3.257.
Page 3152.—In formula for stages between 15 and 20 feet complete the parenthesis thus: $+(20-h)$.
Page 3155.—Feb. 14, in column of "scour or fill" for * substitute †.
Feb. 16, mean velocity, for 4.481 read 3.481.
Page 3157.—The headings in columns of "water area," "scour or fill," "mean velocity" and "discharge," should read *square feet* in the first two and *feet* and *cubic feet*, respectively, in the last two.
Page 3160.—Dec. 1, mean velocity, for 5.381 read 4.381.
Dec. 29, mean velocity, for 4.120 read 4.129.
Page 3161.—Jan. 1, maximum depth, for 3.0 read 63.0.
Page 3162.—March 6, area below datum for 165,511 read 160,511.
Page 3163.—April 22, discharge, for 423,969 read 423,069.
Page 3165.—In table, value of *b*, Dec. 4, for 0.1943 read 0.1953.
In table, last line, for 1890 read 1889.
Page 3167.—Feb. 23, mean velocity, for 4.405, read 3.405.
Page 3168.—March 7, discharge, for 849,723 read 749,723.
Page 3169.—April 4, maximum depth, for 45.0 read 75.0.
Page 3173.—Jan. 31, reading of local gauge, for 29.69 read 29.60.
March 24, number of velocity stations, for 12 read 11.
Page 3174.—Jan. 13, mean depth, for 48.8 read 48.4.
Jan. 29, discharge, for 948,073 read 958,073.
Page 3175.—Feb. 5, fill, for + read —.
Feb. 18, rise or fall, insert "0.0" in blank space.
Page 3176.—March 4, the mean velocity, discharge, and total discharge should be 5.773, 1,067,372, and 1,098,372, respectively, instead of as printed.
April 2, mean velocity, for 5.489 read 5.849.
April 5, mean velocity, for 3.732 read 5.732.
April 4, water area, for 195,501 read 196,501.
Page 3177.—April 26, area below datum, for 192,252 read 192,352.
May 6, area below datum, for 199,854 read 190,854.
April 30, mean depth, for 49.6 read 49.9.
May 7, water area, the following note should be inserted: Adopted from field computation, as sounding notes are incomplete.
Page 3179.—Second paragraph, first line, for continued read continuous.
Third paragraph, second line, take out hyphen after the figure 7.
Page 3182.—Fifth line, for that read than.
Twentieth line, for territory read tertiary.

Page 3183.—Under levels, third paragraph, last line, for 2 feet read 0.2 foot.
Page 3185.—First table, last line, fourth column, insert "0.000" in blank space.
Page 3186.—Second paragraph, fifth line, for chalking read calking.
Page 3187.—First district, balance of funds, for 12,155.22 read 12,165.22.
Page 3188.—Columbus, amount in Treasury, for 6,150.72 read 6,150.92.
Page 3189.—Third district, third line, second column, for 380,410.84 read 390,410.84.
Page 3194.—First district, third column, opposite gauges, for 2,500 read 2,000.
Memphis Reach, eighth column, for 13,500.90 read 13,500.00.
Memphis Reach and Harbor, fourth column, for 138,282.94 read 138,232.94.
Page 3195.—Levees, Yazoo Front (Ben Lomond), sixth column, for 11,385.22 read 11,386.22.
Twelfth line, after Existing works insert protection of.
Page 3199.—Fourth line, for two in approximately straight lines read in two approximately lines.
Page 3200.—Fifth line, omit , after Island.
Twenty-second line, for at depths read of depths.
Forty-third line, for The depths read These depths.
Page 3201.—Under Money statement, first line, for July 1 read June 1.
Page 3202.—Under Plum Point Reach, third column, for 262,910.55 read 262,901.55.
Page 3203.—Under Hickman, Ky., last column, for 48,647.78 read 48,647.76.
Under First district, first column, for Hunter & Trey read Hunter & Frey.
Page 3204.—Opposite No. 5, for Highman read Hickman.
Page 3207.—Under Grand total, Amt., ninth line, for 71,775 read 11,775.
Page 3209.—Opposite Work done, insert feet after 2,717 square.
Page 3210.—Second table, first line, third column, for 31.1 read 31.0.
Page 3211.—Appendix G, fifth line of text, for 130 miles read 180 miles.
Under Memphis Harbor, fourth line, for in the read in their.
The same, fourteenth line, for grass read gross.
Page 3213.—Under Details of Construction, ninth line, for undetermined read undermined.
Page 3216.—In the high-water table, sixth line, for 1889 read 1887.
The same, seventh line, for Mhoen's read Mhoons, and for 1.76 read 1.70.
Page 3217.—Seventh line, for known point read known at that point.
Eighth line, for was 1.15 read was by 1.15.
In the New Madrid table, heading of fourth column, for secood read second.
Page 3218.—In the Memphis table, under Area, Mar. 26, for 147,637 read 146,637.
Page 3220.—Seventeenth line, for conclusion, if reached read conclusion is reached.
Page 3221.—Twenty-first line, for quantitively read quantitatively.
Twenty-fourth line, insert the before restraint.
Thirty-seventh line, for at the flood read of the flood.
Fifth line from bottom, for Hushpuckena read Hushpuckana.
Page 3223.—Heading of next to last table for Survey read Surveys.
Page 3224.—Under Money statement, last column, for 42,771.43 read 42,777.43.
Page 3228.—First table, third line, under Compensation, for 130 read 120.
Second table, third line, under Exports, for 369 read 360.
Second table, thirteenth line, under Exports, for 5,951 read 5,921.
Second table, under Exports, Total, for 93,898 read 93,897.
Page 3231.—Twenty-seventh line from bottom, for the seare read these are.
Page 3233.—Sixth, twelfth, and fifteenth lines from bottom, change comma to decimal point before last two figures in each case.
Page 3235.—Second line, for Vicksburgh read Vicksburg.
Fifth line from bottom, for 40,550.40 read 40,550.49.
Page 3236.—Twenty-eighth line from bottom, for guarantied read guaranteed.
Page 3238.—Fifteenth line from bottom, for link-leather read link leather.
Page 3241.—Sixth paragraph, last line, for 1880 read 1889.
Page 3242.—Thirteenth line from bottom, insert $ before 1.27½.
Page 3250.—First table, third line, under cost, for 1,496.65 read 1,495.65.
Page 3252.—First table, under Greenville Reach, sixth line, insert of after cost.

Page 3253.—In table, eighth line, for 3¾ read 3¼.
The foot-notes are printed on page 3254.
Page 3255.—Twentieth line from bottom, for March 21 read March 31.
Page 3265.—Second table, for Apr. 24 read Apr. 25.
Page 3267.—First table, second line, last column, for 96 read 94.
Second table, fourth line, second column, for 1,657.34 read 1,667.34.
Page 3268.—Seventeenth line from bottom, for Filcher's read Pilcher's.
Eighth line from bottom, for 30 read 20.
Page 3269.—Third line, for slide read side slope.
Twenty-sixth line, for direction read directions.
Ninth line from bottom, for surface read seepage.
Fifth line from bottom, for crevasses read of a crevasse.
Page 3272.—Thirteenth and thirty-sixth lines, for Sterling read Starling.
Page 3273.—Twenty second line, last word, for at read a.
Thirty-fifth line, for number of read numberless.
Twenty-second line from bottom, for floods read flood.
Page 3276.—Report of Mr. J. J. Hoopes, second line, for or read of.
Page 3277.—Table opposite Apr. 11, last column, for 212,497 read 212,479.
Page 3278.—Second table, in discharge at Luna, Mar. 25, put comma instead of decimal point after second figure.
Page 3279.—Opposite Boggy Bayou, under Remarks, for Apr. 3 read Apr. 9.
Opposite Chicot, under Date of observation, for Apr. 11 read Apr. 17.
Opposite Drainage openings, under Remarks, for 248,600 read 148,600.
Opposite Lower side of Catfish, in column of Dates, inclose the four double dates, thus: { Apr. 11. / Apr. 13. }
Opposite Easton, under Discharge, for 52,296 read 55,296.
Page 3280.—Opposite Skipwith's, Apr. 2, under "method used" change do. to Meter.
Page 3281.—Table, Jan. 31, under Total, for 2,050 read 1,050.
Table, heading of fifth column, for on read in, and omit 5.
Page 3282.—Second table, Apr. 17, under area, for 42,095 read 42,075.
First table, heading of fifth column, for on read in, and omit 5.
Page 3283.—Tenth line, after apportioned, insert as follows:
Under the last two financial statements, after the footing insert Balance, June 30, 1890, 0.00.
Page 3284.—Under the last three financial statements, after the footing insert Balance, June 30, 1890, 0.00.
Page 3285.—Fifth paragraph, fourth line, for July, 1890, read July, 1889.
Sixth paragraph, fourth line, for begin read begun.
In heading, for Fred. F. Spalding read Fred. P. Spalding.
Page 3287.—Second line, for works read work.
Under Financial statement, fifth line, insert levees before Lake Bolivar Front.
Page 3288.—Fourth line, for lists read list.
Page 3289.—Under the construction of levees, etc., twentieth line, for the channel read this channel.
Page 3291.—Eleventh line from bottom take out the period after first word.
Page 3292.—First line, put period instead of comma after height.
Page 3293.—Second line from bottom, for 13,500 read 18,500.
Page 3295.—Fifteenth line, for permitted read permit.
Nineteenth line from bottom, for 4.373 read 4.378.
Eighteenth line from bottom, after water-surface insert at the crevasse.
Page 3297.—First paragraph, last line, for 4.82 read 4.2.
Page 3300. Under No. 15, eighth and ninth lines, take out hyphen after horse-shoe and after V.
Last paragraph, third line, after It was insert in.
Page 3301.—Table, second line, under Depth, for 3.5 read 8.5.
Table, opposite No. 4, under High-water mark, for 1.8 read 1.6
Table, opposite No. 30, under Velocity, for 1.3 read 1.8, and under Amount raised, for 2.9 read 2.0.
Page 3302.—Table, opposite Lobdell, under Width, for 1081 read 1981.
Page 3304.—Second line from bottom, for 8 read 6.
Page 3307.—Seventh line, for harbors read harbor.
Page 3309.—Sixteenth line, insert by them after overflow.
Fourteenth line from bottom, for 1888 read 1889.

Page 3310.—Second paragraph, second line from bottom, for 64.301 read 64,301.
Page 3312.—Second line, for 2,000 read 2,900.
Twelfth line, for 1885 read 1883.
Second line above the heading Gauges, for those read these.
Page 3313.—First table, March 5, under Discharge, for 1,251,659 read 1,251,-639.
Page 3315.—Under Money statement, last table, after third line insert July 1, 1890, outstanding liabilities, 0.
Page 3316.—In List of civil engineers, time of W. G. Price at Simmsport, on discharge observations, for 2 months, 1½ days read 21½ days.
Seventh line from bottom, for The space read This space.
Page 3319.—Twenty-first line, for continued read continues.
Twenty-sixth line, for that read this.
Under Hardscrabble Levee, fifth line after levee insert was used to raise the river crown and as a result the levee.
Page 3320.—Under L'Argent to Rifle Point, seventh and eighth lines, for rotton read rotten.
Ninth line from bottom, insert it before difficult.
Page 3321.—Nineteenth line, for were read was.
Page 3326.—Under Panola, second line, for building read buildings.
Under Concordia and Fletcher, third line, for sea read seep.
Page 3330.—Under Cost and material were, fifth line, for 3 by 6 feet read 3 by 6 inch.
Fifteenth line from bottom, for Gouldsborough read Goulds-boro.
Page 3332.—Fifth line, insert inch after 3½.
Eighteenth line from bottom, for Spur No. 3 read Spur No. 2.
Seventh line from bottom, for $45.21 read $54.21.
Page 3333.—Eleventh line, for 119.40 read 11,940.
Second line from bottom, for 40 by 136 read 40 by 145.
Page 3334.—Eleventh line, for $2,513.78 read $1,513.78.
Page 3337.—Under Surveys, second line, after Morganza insert Reach.
Page 3346.—Under Stonewall or Lanaux crevasse, last line, for in levee read of levee.
Page 3347.—Under Preston crevasse, eleventh line, for 4 by 4 feet read 4 by 4 inch.
Page 3354.—Fifteenth line from bottom, for 1880 read 1890.
Seventh line from bottom, for hauled read handled.
Page 3355.—Tenth line, opposite Wrapping paper, for 672 read 679.
Page 3356.—Sixteenth line from bottom, opposite Wooden-ware, for 3,509 read 3,500
Page 3357.—Twelfth line, opposite Groceries, for 352,032 read 52,032.
Thirteenth line, opposite Wooden-ware, for 2,030 read 32,030.
Under Articles of cargo, opposite corn, for 14,895 read 14,896.

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APPENDIX W W.

ANNUAL REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

THE MISSISSIPPI RIVER COMMISSION,
PRESIDENT'S OFFICE,
New York, June 30, 1890.

SIR: The Mississippi River Commission submits herewith its annual report for the fiscal year ending June 30, 1890.

At the date of its last annual report, for the reasons therein stated, no large amount of work had been done by the Commission under the appropriation contained in the river and harbor act of August 11, 1888. During this year the work has been vigorously prosecuted and, with the exception of some of the special local appropriations, the appropriations are now practically exhausted.

During the most of the year the Commission has not had sufficient funds available for its own expenses; to hold meetings or to obtain by personal inspection of the works the knowledge of their condition indispensable to an efficient supervision.

It had been expected that considerable balances would be available during the coming low-water season for the prosecution of the works, especially at Lake Providence; but the flood of 1890 supervened and threatened the destruction of levees from Helena to New Orleans, which were of greater strength and in better condition than ever before. Nearly all balances available were diverted to holding these levees (some of them constructed by the United States) in order to save the expense of their reconstruction and the widespread injury that would be done to all the lands behind them in case they should break. About $220,000 was diverted from other balances and applied to this purpose. While the attempt was not entirely successful, the extent of the disaster was largely reduced by the exertions of the local authorities and by the use of the funds supplied by the Commission. Out of an aggregate length of levees on the Mississippi below Cape Girardeau, amounting, when the flood began, to 1,294 miles, the aggregate amount of breaks during the flood was but 6.5 miles. The district officers were energetic and untiring in their endeavors to hold the levees. The important breaks were all below the Arkansas River, and from that point to New Orleans, with the exception of Vicksburg, the river was higher than ever before known.

If the flood be considered as to its maximum discharge, it was also a great one, though not as great as that of 1882. Captain Leach estimates the maximum discharge across the parallel of Helena at 1,617,000 cubic feet per second, and as 231,000 cubic feet less than that of 1882. Captain Young estimates the maximum discharge at Arkansas City, including crevasse escape, at 1,721,000 cubic feet per second on April 13,

1890. In 1882 it was estimated at about 2,000,000 cubic feet per second. Captain Kingman estimates the maximum flow across the parallel of latitude at the mouth of the Red River at 2,031,587 cubic feet per second on May 7, 1890. In 1882 it was estimated at 2,200,000.

Much valuable information in reference to the flood of 1890 will be found in the reports of the district officers. The lesson taught by the flood is the same as that of other great floods, namely, the necessity of raising and strengthening the levees.

The survey of the Mississippi River has been continued. Under the wording of the appropriations, it is not specifically under the control of the Mississippi River Commission, although the Secretary of War has so assigned its expenditure. Since the investigations made in this survey are, some of them, especially necessary to the Commission, the appropriations might well be among the Commission appropriations, as was formerly the case.

As to the results obtained by the expenditure of the last appropriation, it may be said that in general the work done by the Commission during the year has been successful, and is producing the results desired. In the improved part of the Plum Point Reach, the least navigable depth in 1888 was 13.5 feet, and in 1889 10 feet. In that part of the Lake Providence Reach where work has been done, the least navigable depth in 1888 was 9 feet, and in 1889 8 feet.

A detailed account will now be given of the work done in the last year, supplemented by appendices containing the reports of the officers in immediate charge of the works.

SURVEYS AND EXAMINATIONS.

This work has been in charge of Capt. C. F. Powell, Corps of Engineers, the secretary of the Commission. During the year the survey of the Mississippi has been completed from Chester, Mo., to Alton, Ill. The triangulation is complete to Keokuk, Iowa, and the precise levels to Fulton, Ill. Editions of 36 sheets of the $\frac{1}{20000}$ map of the Mississippi River have been printed, numerous discharge observations have been re-computed, and much miscellaneous work has been done. For details see Captain Powell's report, Appendix E.

GENERAL SERVICE.

This has been in charge of Capt. C. F. Powell, and the work has been mainly confined to the delivery of stone to various works and to building barges. There were delivered to the first and second districts 19,134 cubic yards of stone. The barges under contract at the last report were completed and ten new barges built. Repairs were made to the general service steamers.

The towage cost of stone and coal by the general service has been computed for the seven years ending December 30, 1889, at 6.2 mills per yard-mile, thirty-eight months of work and forty-six months of suspension. The relative cost of towage in the low water of 1888 and the high water of 1889 was found to be 2.8 mills per yard-mile for the former and 2.4 mills for the latter. For details see Captain Powell's report, Appendix E.

First district.

(Cairo to foot of Island No. 40, 220 miles. Officer in charge, Capt. S. S. Leach, Corps of Engineers, U. S. Army. Headquarters, Memphis, Tenn.)

(*a*) *Columbus, Kentucky, 21 miles below Cairo.*—The expenditures at this point have been from specific appropriations in the acts of 1886 and

1888, amounting together to $43,750. The approved project provided for a revetment of 5 spur-dikes to protect about 2,200 linear feet of bank threatened by caving.

The same plant being used at Hickman and Columbus, only preliminary work was done at the latter place before completion of the work at Hickman. Construction was begun early in December, 1889, and continued under difficult conditions of river and weather for nearly a month, when the approach of high water caused it to be suspended, one-half the work being accomplished. It is expected that operations can be resumed in time to complete the protection during the summer. No further appropriation asked for.

(*b*) *Hickman, Kentucky, 36 miles below Cairo.*—Caving has been going on at the upper part of the town, and about 1,000 feet of the bank has been protected, the upper end of the mattress revetment resting on a hard point of indurated clay. The expenditure has been from specific appropriations in the acts of 1886 and 1888, amounting together to $88,750. The form of the shore and the character of the strata of which it is composed compelled the adoption of special methods of anchorage and of grading, and gave the work a somewhat higher cost than usual. The mattress was begun October 4 and finished October 24, 1889, the cost of the work being $24.10 per linear foot. It does not appear that any displacement has occurred during the flood of this year.

Above the clay point already referred to, the alluvial bank is caving rapidly; but until the clay point wears away, which may not be for several years, the caving at the upper end of the town can be stopped with the balance of the appropriation remaining on hand. Should Congress deem it advisable to carry the protection along the low bottom above the clay point $111,250 additional would be needed.

(*c*) *Plum Point Reach, 147–186 miles below Cairo.*—(1) *Fletcher's Revetment.*—The allotment for this work from the appropriation of 1888 was $131,000. The approved project was for the construction of 7,400 feet of mattress revetment in five sections, of which there remained unfinished at the time of the last annual report 2,100 feet, in two sections. Work on these sections was begun towards the close of May, and after some delays due to the stage of water in June and July, was finished by the middle of September, 1889.

The 7,400 feet of revetment constructed in the two seasons is distributed along a distance of nearly 13,000 feet, the upper part being 3,000 feet in continuous length, and the lower part being divided into four sections, each 1,100 feet in length, and separated by intervals of 300, 400, and 500 feet. Between these two parts is a space of 3,800 feet, near the middle of which a false point formed by a piece of old work, until recently projected into the river. This interval was left unprotected in order that the point might cave back to the line of the new work. This caving took place during the high water of 1890, and it is proposed that the upper section of revetment be extended down stream to cover this part of the bank.

The experiment has been tried at the lower part of this bank protection of revetting lengths of 1,100 feet of bank, leaving intervals of 300 to 500 feet between them unrevetted, to see if this would give an efficient bank protection while reducing cost. Thus far the protection seems to be sufficient, but the test has not yet been long enough to enable final conclusions to be drawn.

(2) *Plum Point Revetment.*—A piece of mattress revetment 800 feet long has been placed half a mile above Plum Point Landing to check caving that threatened the stability of the crossing just below.

(3) *Daniell's Point Revetment.*—As rapid caving was going on in the bend above Daniell's Point, which threatened to disturb the regimen of the river below, its protection was undertaken. The approved project provided for a revetment of about 5,000 feet in length, at an estimated cost of $100,000. The work as completed January 14, 1890, forms a continuous protection of 5,300 feet from the extreme point up, and is designed to fix the channel of the river, which was in danger of deteriorating from the caving at the point and in the bend above. To meet the great strain to which it would be subjected the work was heavier than usual, and was constructed with especial attention to details. The cost per foot was therefore relatively high, being about one-third greater than that of the continuous portion of the Fletcher revetment.

(4) *Elmot and Island No. 30 Dikes.*—As noted in the last annual report, this work was suspended after the greater part of the foot mat was laid, because of the low stage of water in 1889. It was resumed in February, 1890, and after some interruption by high water is now within a few days of completion.

Results.—The least low-water depth through the part of the Plum Point Reach which has been improved was 13.5 feet in the very low-water year 1888, and 10 feet in 1889. This improvement on the original low-water depth of about 5 feet is necessarily accompanied by a reduction in the steep low-water slopes which formerly existed over the bars. The low-water fall from Daniell's Point to Craighead Point, a distance of 20 miles, was about 2.8 feet less in 1889 than in 1879.

For details of work in the first district, see report of Captain Leach, Appendix F.

Second district.

(Foot of Island No. 40 to mouth of White River, 180 miles. Officer in charge, Capt. S. S. Leach, Corps of Engineers, U. S. Army. Headquarters, Memphis, Tenn.)

(*a*) *Memphis Reach, 226 miles below Cairo.*—But little work has been done during the year. In the original design of the system of dikes known as the "Citizens' Protection," it was expected that natural deposits of silt would replace the perishable brush. This natural accretion not taking place, it was decided to protect the uppper ends of the dikes with a covering of earth and pavement of stone, and this plan was carried out with four of the dikes. Dike No. 1, being of less importance, was left untouched, and is now entirely masked by earth dumped above it by various parties.

In consequence of the recession of Hopefield Point a bar has formed at the upper part of the harbor, cutting off access at low water to the levee above the elevator. A plan to remedy this difficulty is now before the Commission for consideration at their next meeting.

The only damage occasioned by the flood of this year is a fault of 500 feet in the upper work of Hopefield revetment, which will be repaired during the coming season.

The district officer submits an estimate for the fiscal year 1892 of $37,000 for Memphis Harbor.

(*b*) *Helena Harbor, 306 miles below Cairo.*—The approved project for this plan, under a specific appropriation of $75,000 in the act of August 11, 1888, provided for the protection of 3,000 feet of bank by 600 feet of continuous revetment in front of the elevator, and a system of five spur dikes further down, together with a drainage canal to carry off swamp water from the back of the levee. The canal was finished about the close of the last fiscal year, and the mattress work at the

elevator in September, 1889. Dikes 1 and 2 are finished, the other three are still incomplete.

The dike construction was attended with unusual difficulties from the force of the current and the interference of drift, and two floor mats in succession were lost at Dike No. 1. This with sliding of the bank from No. 4 to No. 5, which required extension of work at those dikes, made it impossible to finish the protection within the appropriation. Fifteen thousand dollars additional is needed to complete the work.

LEVEES, FIRST AND SECOND DISTRICT.

The levee at Laconia Circle, above the mouth of White River, was overtopped by the flood which was here 2 feet higher than any previously recorded. The only break in these districts was a small one at Austin, Miss., 288 miles below Cairo. The plum Point levees were watched and cared for. Those near Helena were protected mainly by the local levee board. The Mississippi levees in the second district were attended to exclusively by the State authorities.

For details of work in the second district, see report of Captain Leach, Appendix G.

Third district.

(Month of White River to Warrenton, Miss., 220 miles. Officer in charge, Capt. W. T. Russell, Corps of Engineers, U. S. A., to December 20, 1889; since then Capt. W. Young, Corps of Engineers, U. S. A. Headquarters, Memphis, Tenn.)

(*a*) *Lake Providence Reach.*—The work during the past year has been confined to bank protection in Louisiana Bend. The approved project contemplated the protection of about 4 miles of bank by a subaqueous mattress 260 to 300 feet wide, and an upper bank covering of riprap.

The work at this place is an exceedingly difficult one in consequence of the depth of water and swiftness of the current. An attempt at sinking the upper end of a mattress while weaving was continued at its lower end, resulting in its partial loss. On account, it is supposed, of the softness of the bank, several slips took place which necessitated the use of supplementary mattresses. These accidents, and the use of stone for the upper bank revetment, made the work done very expensive,—much more so than it should have been without these accidents, and hence not giving a just idea of the cost under ordinary circumstances.

The least depths in the year on the crossings of the reach affected by the works, were at Duncansby, 17 feet, Vista, 8.5 feet, and Stack Island, 11 feet. At Ben Lomond the depth went down to 8.5 feet, and to 7 feet at Ajax Bar, both crossings being below the works of improvement.

(*b*) *Vicksburg Harbor and Delta Point.*—The work here has two objects: First to hold Delta Point by revetment work and thus prevent its further recession, which would allow the Mississippi to abandon the present Vicksburg front entirely instead of partly, as is now the case; second, to form a dredged canal leading to a dredged basin whose bottom is to be 5 feet below low water at the upper part of the city of Vicksburg.

The Delta Point Revetment, covering 10,700 feet of bank, has so far been entirely successful, and has required no repairs during the past year. New work will probably be required to check caving above.

Dredging in Vicksburg Harbor has been continued this year, principally in the canal connecting the basin with the river below. As the work can be carried on only when the river is above mid stage, very little was done after the date of the last report, until February of the

present year. No appreciable fill had taken place in the basin in 1889, and that in the canal has been confined to a limited area. The dredging of this season, which is done partly by contract and partly by Government plant and hired labor, will probably reach a plane 8 feet above low water. The estimate of the local officer for the fiscal year 1892 is $175,000.

(*c*) *Greenville Harbor.*—In previous years ten spur-dikes have been built in front of the city, in part by the city itself, and with some repairs have held the front of the town satisfactorily from further caving. But caving has been going on above the dikes for a long distance, threatening ultimately both them and the city. A little work had been done above the city, but the partly completed revetment was much damaged by the high water of 1889. Instead of repairing and extending this mattress, it was decided to protect the bank by means of two crib-dikes at and below the site of the old mattress, and, by a pile-dike in the form of an obtuse salient, covering a caving-pocket just above the old system of spurs. Between these later constructions there remains a space of about 1,500 feet, and above the upper crib dike about 5,000 feet, of exposed bank, all of which will need protection. The estimate of the local officer for the fiscal year 1892 is $350,000.

(*d*) *Lake Bolivar Front.*—A special allotment for this work was made by the river and harbor act of August 11, 1888. The object of the improvement is to stop the caving of the bank in front of the large and costly levee across the end of Lake Bolivar, which was threatened by the rapid encroachment of the river. During the latter part of 1888 and the beginning of 1889 a part of the bank immediately in front of this large levee was revetted. This work, so far as carried out, was perfectly successful in stopping caving; below the work the bank is caving rapidly.

The work done during the year consisted simply in repairing some of the revetment. The estimate of the local officer for the fiscal year 1892, is $100,000.

LEVEES, THIRD DISTRICT.

A.—*Construction.*—No work of construction has been done during the year except on the Tensas Front, a small enlargement below Lakeport in September, 1889, and raising sunken places in Whiskey Chute and Grand Lake levees in January, 1890, in anticipation of the flood.

B.—*Protection during high water.*—By the end of January it was evident that a considerable flood was to be expected, and an inspection of the whole line was made, with such repairs and strengthening as seemed urgent. The State and other levee organizations took up the work vigorously, and continued it until their means were exhausted; after the end of March the United States Government alone had funds for protection of levees in Louisiana in this district. The work in Arkansas, as heretofore, was under direct Government supervision. Mississippi asked for no aid, except in holding the ends of levees at crevasses.

The first break in the Tensas Front levees occurred March 9, 9 miles above Arkansas City, and the first on the Mississippi side at Offuts, March 18. Breaks occurred at seventeen places in this district, with an aggregate length of $3\frac{3}{4}$ miles.

Except in some minor cases it was found useless to attempt the closure of the openings, and efforts were confined to holding, by one or other device, the broken ends of the levees, and so checking the en-

largement of the breaks. Several plans were tried, with varying results; the most successful being the employment of spur-dikes made of piling, brush, and sacks of earth, to break and deflect the current, and mattresses to cover the broken ends of the levees and prevent further erosion.

The overflow limits on the right bank in this district included 3,050 square miles, of which all but 550 was under water. On the left bank the whole area within the overflow limit was near 2,000 square miles, of which 1,900 was under water. The United States boats, in addition to their other work, were employed in the relief of people in the flooded region.

Miscellaneous.—Discharge observations were made at Arkansas City and Wilson's Point, on the main river, and at the principal crevasses. The results indicate a maximum flow past the latitude of Arkansas City of about 1,700,000 cubic feet per second, of which 1,300,000 could be confined by the levees at their present grade.

Surveys were made of the Lake Providence Reach and of the Greenville Bends. These surveys indicate no immediate danger from cut offs except at Ashbrook Point, where the distance across the neck is now 2,400 feet, and is decreasing at the rate of 300 feet yearly. A cut-off here would shorten the river 8 miles or more.

For details of work in the third district see report of Captain Young, Appendix H.

Fourth district.

(Warrenton, Miss., to Head of Passes, 484 miles. Officer in charge, Capt. D. C. Kingman, Corps of Engineers, U. S. Army. Headquarters, New Orleans, La.)

(*a*) *Improvement at Natchez and Vidalia.*—The danger apprehended here is the formation of a cut-off across the point above the town. As its prevention would require the protection of a large amount of caving bank, its cost would be great; it has been estimated at $750,000.

No work has been done during the year in protecting caving banks or upon the proposed spur levee on Cowpen Point. Fears have been recently expressed by the citizens, and a survey will be made when the river shall have reached a suitable stage.

(*b*) *Rectification of Red and Atchafalaya rivers.*—The project here is to limit the flow down the Atchafalaya by means of dams submerged sufficiently to permit navigation over them, and, at stages below 10 feet, to make the Red River flow north of Turnbull's Island directly into the Mississippi by building a low dam on the west side of Turnbull's Island and a dike from its lower end to the Mississippi. Then at low stages the Atchafalaya will be an outlet of the Mississippi and will receive water from it alone. Until these works are completed attempts must be made to keep the mouth of the Red River open during low water by dredging.

Of the six submerged dams projected for the Atchafalaya, No. 1 had been finished and the sill of No. 3 partly laid by July 1, 1889. Since then No. 3 has been completed. Some changes will have to be made in these dams to equalize the high-water capacity of the water-ways over them; at present the high-water area over dam No. 1 is about one-fourth greater than that over dam No. 3, involving a concentration of fall at the latter place and a velocity unfavorable to navigation. These dams have remained intact through the flood.

The sill for the dam designed to deflect the low-water flow of Red River into the channel north of Turnbull's Island has been laid.

Dredging was carried on in Lower Old River during low water, with

the result of keeping the channel open throughout the season, although for a few days it was practicable only for small and light-draught boats.

The estimate for the fiscal year 1892 is $350,000.

(*c*) *New Orleans Harbor.*—The object of the work at New Orleans is to hold the river in its present position by protecting caving banks. As the depths are exceedingly great—in places as much as 150 feet—and in many places the banks very steep, the method of protection mostly used is that of spur-dikes about 1,000 feet apart, which, starting from near low water, project into the river, sloping downward in the direction of their length at the rate of about one foot vertical to three horizontal (or having a top slope of 1 : 3) till the slope reaches the river-bed. The project includes work in the bends at Carrollton and at the lower part of the city (third district), on the left bank, and at Greenville and Gouldsboro on the right. Prior to July 1, 1889, mattress revetment had been begun at Carrollton, but work had been stopped; a system of six spurs had been completed in Gouldsboro Bend, and one large spur partly finished in Greenville Bend.

During the past year the first spur at Greenville has been finished and a second built, and four spur-dikes have been built in the third district, completing the improvement for that point. No further caving has taken place, and so far as can be ascertained at the present stage of water the works have perfectly withstood the flood. In the third district, where the caving had encroached upon the street, the dikes were carried up over the batture and connected with the levee by paved embankments. Here the falling water shows a deposit of silt on the batture from 1 to 3 feet in thickness.

Six spurs remain to be built in the Carrollton Bend, where considerable scour is said to have taken place during the past flood, and where there may be heavy caving as the river falls. Materials in part are on hand, and work will be begun as soon as a proper stage of water is reached.

The estimate for the fiscal year 1892 is $200,000.

Surveys, examinations, and inspections.—Surveys have been made in the caving bends at Lakes St. Joseph, Bruin, and St. John to determine how far the levees crossing the ends of these lakes are endangered by the progressive caving. At the present rate of caving it appears that the Lake St. Joseph levees are safe for several years to come, unless the more rapid caving above should work down-stream. At Lake Bruin the rate of bank recession is such that the levee will be reached in about three years. At Lake St. John the caving is slow and the levee is not immediately threatened.

At Morganza crevasse there has been little or no change in the river cross-section since 1887, the water of the next two seasons not having been high enough to make the levee any factor in the river regimen.

Gauge records have been kept at several points and the results reported to the Secretary. Circulars asking for information about high-water marks during the flood of this year were distributed with the request that the answers be sent to the Secretary. So far as learned the flood, from New Texas Landing down to Hermitage, was from 1.2 to 1.9 feet above that of 1882.

A full set of high-water discharge measurements was obtained at Carrollton and one less complete at Red River Landing, and detached observations were made at Warrenton, Natchez, and Baton Rouge, as well as at Simmsport, on the Atchafalaya. Captain Kingman submits

the following estimates of maximum flow across the latitude of Red River Landing:

	Cubic feet per second.
Mississippi River, May 7	1,487,362
Atchafalaya River (between levees)	474,225
Atchafalaya River (crevasse escape)	70,000
Maximum passing latitude of Red River Landing	2,031,587

LEVEES.

A.—*Construction—Tensas Front.*—Since the last annual report the Hard Times-Wilson levee has been finished. This levee contains over 700,000 cubic yards of earth, and with protection levees and drainage ditches its construction involved moving nearly 800,000 cubic yards. The levee proper is a little over 10 miles in length, and with the protection levees about 11½ miles. It is the largest single levee built by the United States, and runs through a very difficult tract of country, swampy and covered with heavy timbers, and intersected by lakes and sloughs. It has not been damaged by the flood, though caving just above its upper end threatened in January to take it in flank.

B.—*Protection during high water.*—In November and December, 1889, a survey was made to ascertain the condition of the levees on the Tensas Front. The Hard Times Levee, at Lake St. Joseph Crossing, where it was low, was raised, and work on low places in Kempe Levee was carried on until interrupted by high water.

After the first allotment of $25,000 for protection of levees, March 12, a steamer and barge, with tools and materials, was sent to the Tensas Front and rendered valuable aid in protecting levees. Three breaks occurred in this part of the district, April 22 and 23, all in the vicinity of Natchez.

Below Red River the first important break was the Nita crevasse, on March 14, which gradually enlarged until its measured discharge was 400,000 cubic feet per second. In Pointe Coupée parish, from Smithland to Point Manoir, a distance of 40 miles, the levees were too low, and there is scarcely a mile in that distance upon which work was not necessary. To keep the water from their rear work was also needed on levees through to the Atchafalaya and down its left bank. The Morganza Levee, 8,000 feet long, was raised from 1 to 2 feet, and Grand Levee was raised about 1 foot. In spite of all efforts there were numerous breaks between April 20 and 23 in the district below Red River, the Morganza Levee being one of those broken.

As a rule the efforts of the Commission were directed to the prevention of breaks, and to checking the enlargement of those that occurred. To have attempted to close the crevasses at once would have required unlimited funds.

Detailed information in reference to the breaks in the levees during the flood will be found in Captain Kingman's report, Appendix I.

FINANCIAL STATEMENTS.

Appropriation for salaries and expenses Mississippi River Commission:	
Balance on hand June 1, 1889	$14,197.29
Received from transfers	394.80
Total	14,592.09
Expended from June 1, 1889, to June 30, 1890	14,475.59
Balance on hand July 1, 1890	116.50

Appropriation for deficiencies Mississippi River Commission:	
Balance on hand June 1, 1889	$4,214.39
Returned to Treasury	4,214.39
Appropriation for surveys of Mississippi River:	
Balance on hand June 1, 1889	51,965.16
Expended from June 1, 1889, to June 30, 1890	48,085.00
Balance on hand July 1, 1890	3,880.16
Appropriation for improving Mississippi River:	
Balance on hand June 1, 1889	1,876,031.16
Less expenses office Chief of Engineers	4,289.00
Balance, net	1,871,742.16
Refunded on sundry accounts	4.39
Total	1,871,746.55
Expended from June 1, 1889, to June 30, 1890	1,496,128.21
Balance on hand July 1, 1890	375,618.34

ESTIMATE OF FUNDS FOR THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

For the Mississippi River Commission: For salaries, inspections, and traveling expenses of the Mississippi River Commission; for printing and telegraphing; for office expenses and miscellaneous	$35,000
For surveys and examinations of the Mississippi River from the head of the passes to its headwaters—continuing survey	150,000
For improving the Mississippi River from the head of the passes to the mouth of the Ohio River	4,000,000
For work at—	
Hickman, Ky	111,250
Greenville, Miss	350,000
Vicksburg, Miss	175,000
Natchez, Miss	250,000
New Orleans, La	200,000
Red and Atchafalaya rivers	350,000

C. B. COMSTOCK,
Colonel of Engineers and Bvt. Brig. Gen.,
President Miss. River Commission.
CHAS. R. SUTER,
Lieut. Col. of Engineers, U. S. A.
B. M. HARROD.
R. S. TAYLOR.
O. H. ERNST,
Major of Engineers, Col. U. S. A.
HENRY FLAD.
HENRY L. WHITING,
Assistant U. S. C. and G. Survey.

The SECRETARY OF WAR,
Through the Chief of Engineers, U. S. A.

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APPENDIX A.

MEMORANDUM ON THE QUESTION WHETHER BUILDING LEVEES ALONG A RIVER CAUSES ITS BED TO RISE.

The statement is often made that leveed rivers raise their beds higher and higher as levees are raised, and hence that levees will give no permanent relief against overflow. These statements are usually made from theoretical opinions, and without a thorough knowledge of the theoretical side of the subject, and probably without any knowledge of the facts of experience, which alone can lead to conclusions entirely safe.

The river Po has long been leveed, and it is often stated that its bed has risen largely in consequence of levees. The following data will show how unfounded is the statement that the bed has risen by amounts that are of much importance:

At the revival of civilization the levees on the Po were complete and continuous from Cremona to the mouth of the Oglio, 94 kilometers, or 58.4 miles. About A. D. 1300 they were carried farther down the river, and in the succeeding centuries to near its mouth. In the present century levees have been systematized as to height. Four hundred kilometers, or 248½ miles, were below the flood of 1872; at the end of 1877 it was expected to reduce this to about 30 kilometers, or 18 miles. (Cenni monografici sull' idraulica fluviale in Italia. Roma, 1878.)

Zendrini, in 1720, observed an extreme low water at Ponte Lagoscuro, only 0.36 foot less than that of 1817; and at the dam of Governolo, near the mouth of the Mincio, the river was 1.3 feet lower than a stage of water of 1609, declared by Bardazzoli to be marvelous. (Lombardini Notizii.)

The Cenni Monografici gives the following:

Ponte Lagoscuro.

Period.	Mean lowest water.	Mean highest water.	Maximum high water.	Minimum low water.
1807-1825	$3^m.28 = 10.4$ feet	$7^m.42 = 24.3$ feet	$8^m.62 = 28.3$ feet	$0^m.38 = 1\ 3$ feet.
1826-1850	$3^m.26 = 10.3$ feet	$7^m.38 = 24.2$ feet	$8^m.96 = 29.4$ feet	$0^m.72 = 2.3$ feet.
1851-1875	$3^m.19 = 10.1$ feet	$7^m.39 = 24.2$ feet	$9^m.32 = 30.5$ feet	$0^m.62 = 2.0$ feet.

The above gauge-readings, which have only been kept since 1807, show that there has been no important rise of the bed of the river (since that could not rise without raising the low-water surface) at Ponte Lagoscuro in the sixty-eight years covered, and, in connection with Zendrini's observations, show that there has been no probable rise of any importance since 1720, although the raising of levees has been going on during this period.

Lombardini (Dei cangiamenti del Po, 1852, p. 17) examines this question for points above Ponte Lagoscuro, which itself is 92 kilometers (57 miles) above the mouth. He concludes that at Ostiglia, which is 183 kilometers (114 miles) above the mouth, the bed appears to have risen a few decimeters (decimeter = 3.9 inches) in a century, while at Governolo, 15 kilometers, (9⅛ miles) above, it appears to have been stationary for four centuries. In Il grande estuario Adriatico, 1868, App. D, he gives the following table of mean heights of extreme low waters above the lowest water known, which was in May, 1817:

Period.	Ostiglia.	Sermide.	Quatrelle.	Ponte Lagoscuro.
1817–1850	0m.55	0m.54	0m.47	0m.49
1851–1867	0m.44	0m.77	0m.84	0m.55

Comparing the means from 1817 to 1850 with those from 1851 to 1867, it will be seen that a small rise in low-water heights is indicated, but the observations at several stations in the first period were few, and hence the results are uncertain.

The flood heights have, however, steadily risen. The following greatest floods are recorded:

1705—1756 (in the year 1755) ..... 1m.82= 6.0 feet
1754—1796 (in the year 1777) ..... 2m.15= 7.1 feet
1797—1836 (in the year 1833) ..... 2m.68= 8.8 feet
1837—1877 (in the year 1872) ..... 3m.22=10.6 feet

From this statement it appears that the highest floods have increased in height since 1705 by 1.4 meters equal to 4.6 feet. The rise in flood heights on the Po has not been confined to the single point Ponte Lagoscuro, but has extended far above.

Gallizia (Giornale del genio civile, February, 1878) examines this question and gives the following result (the miles given are reckoned from the mouth of the river):

"At Bocca (394 kilometers equal to 245 miles), within the century, there is a progressive rise of 1.53 meters (5 feet), from 1801 to 1857. At Corossa (337 kilometers equal to 209 miles) the flood of 1801 read 6.35 meters, and their heights rose gradually to 7.95 meters in 1872, or to 7.45 meters, if allowance is made for a change of bed at this place. At Casal Maggione (233 kilometers equal to 145 miles), from 5.60 meters in 1801, the floods rose gradually to 6.07 meters, in 1868, a rise of 0.47 meters (1½ feet). At Ostiglia (149 kilometers equal 73 miles), from 6.80 meters in 1801, and 7.50 meters in 1812, to 8.56 meters, although the river was not entirely confined. At Ponte Lagoscuro (92 kilometers equal 57 miles), from 2.19 meters *sopra guardia* in 1801, to 3.32 meters in 1872—the river not being entirely confined in this last year—a rise of 1.13 meters (3.7 feet); so that on the average there has certainly been a rise of more than a meter (3.28 feet) in the last seventy-five years along the whole course of the leveed river, excluding the Parma, Cremona front, where the levees are far apart, and the rise is about one-half as much.

"Cenni monografici sull' idraulica, page 59, attributes the increased heights of the great flood of 1839 to "the more perfect leveeing of the Po and its tributaries, preventing the lateral escape of the waters, and sending in a canal to the sea that which previously flowed over the country.

"Lombardini (Il grande estuario Adriatico, p. 96) says the increased floods 'arise in part from levees, which hinder their spreading out, and also from the deforesting of mountain slopes."

Gallizia (*loc. cit.*) attributes increase of floods to deforesting, to the interest each one has to get rid of injurious water without consideration for those below him, to the leveeing of upper parts of rivers and their tributaries, and to the extension of the river mouth into the sea.

To sum up in reference to the Po, it may be said that during the present century the levees on the Po have been systematized and raised to follow an increase in flood height that in seventy-five years amounted to about 3 feet along the leveed portion of the river; and that there is some evidence of a small rise in the extreme low-water surface of the river, which may be caused by a rise of the bed. It should be noticed, however, that the rise in the bed (if it really exists) amounts to only two-hundredths of a foot a year, and that the annual cost of raising levees, to keep up with it, would be but a small part of the annual cost of a complete system of levees.

As to the rise in the flood level as the waters are more and more thoroughly confined, it may be said that this was a necessary result of confinement, that the same thing occurs on the Mississippi, and that it will cease when the levees have been built high enough to contain the greatest floods. On the Po thus far during the last seventy-five years the effect of the confinement of waters in raising the flood level has far exceeded any tendency that confinement may have had to reduce flood heights by scouring the bed.

The Rhine is also a river which, below Düsseldorf, has long been leveed, and if levees raise the bed of a river here they should have produced their full effect, as they are rarely broken.

The following table from Fijnje (Beschoūwingen over eenige rivieren erste gedeclte, bijlage A, page 185) gives (in meters) the height of the lowest water which occurred in each ten years from 1772 to 1880, above the Amsterdam zero, for Cologne and Emmerich:

Period.	Cologne.	Emmerich.	Period.	Cologne.	Emmerich.
1772-1780	36.82	11.29	1831-1840	36.30	10.88
1781-1790	36.14	11.26	1841-1850	36.35	10.81
1791-1800	36.36	11.24	1851-1860	36.06	10.16
1801-1810	36.56	11.11	1861-1870	36.03	9.92
1811-1820	36.30	11.03	1871-1880	36.28	10.21
1821-1830	36.30	10.64			

It will be seen that the low-water surface appears to have fallen in the last hundred years at Emmerich, and possibly at Cologne.

Hagen (Wasserstände in den Preussischen Strömen, page 12) carefully examines the gauge-readings at Cologne from 1846 to 1879 and at Düsseldorf from 1800 to 1879 to detect changes in high and low water heights. Treating the gauge-readings by the method of least squares he found the most probable annual change in the water heights. At Düsseldorf he found that with great probability there was an annual sinking of the maximum high water in each year amounting to 0.3 inches; that the mean stage did not change, and that the annual lowest waters showed with some probability an annual rise of one-twelfth of an inch.

For Cologne he found that with great probability the high waters had sunk and the lowest waters had risen by about the same amounts as at Düsseldorf. A rise of one-twelfth of an inch in a year or 8 inches in a hundred years is so small as not to be an important matter in a system of levees, and if the hundred years of the table above are taken the rise disappears.

It has often been asserted that the bed of the Hwang-ho, or Yellow River of China, has risen above the surrounding country, where it is leveed. The error, originally due to Abbé Huc, has been repeated by English writers on China. The following extract from a letter to me by Gen. J. H. Wilson (a very competent authority) gives reliable information on the subject:

WILMINGTON, DEL., *May* 6, 1890.

* * * * * * *

In reply I hasten to say that I crossed the Yellow River on the 7th of January, 1866, near the city of Kai-fung-fu, in the province of Honan, and visited the site of the overflow of 1853, about 30 miles below Kai-fung-fu. I also traversed its embankments, or levees, on both banks of the river, visiting them and measuring them at various points between Kai-fung-fu and Chinan-fu, in the province of Shantung, taking observations, notes, and measurements, and having especially in view the repair and maintenance of the embankments, their present condition, and the effects produced by them. I had no instruments, however, except a hand-level, sextant, and tape-line, and could therefore make no accurate levels across embankments, bed of the stream, fore-shores, and adjacent plains; but the conclusion I came to in regard to the influence of the levees upon the bed of the river was that they had nowhere filled it to a higher level than the adjacent country. I had heard of Father Huc's narrative on that point, and I visited the place at which the river had left its old channel in 1853, leading to the sea south of the peninsula of Shantung, and made itself an absolutely new one to the Gulf of Pechili, north of that peninsula. Between this place—known on the maps of Asia (Keith Johnson's is the best) as Lung-mun-ku—and Kai-fung-fu the embankment was very large, but it was near the latter place that the great breach occurred two years ago. This was closed after incredible efforts and great expense, and the river forced to resume its old channel to the Gulf of Pechili, where it is now emptying itself, according to my advices of a

few months ago, and where it will most probably continue to empty itself till it can find a shorter line and steeper declivity to tide level.

By referring to my little book on China (Appleton & Co.) you will get other details.

In conclusion, I do not hesitate to say that I can not but believe that Abbé Huc was entirely mistaken in regard to the silting up of the channel, and that an exhaustive survey would prove beyond a doubt that no such silting as to raise any part of the bed above the adjacent country has ever taken place.

Yours, very truly,

JAMES H. WILSON.

The question of the rise of bed of the Mississippi will now be considered. Unfortunately it has not been studied as thoroughly as the Rhine and Po, and its gauge records go back but a few decades.

Levee building has gone on most rapidly since 1880, and as the river was very low in December and January, 1887–'88, and again in October and November, 1889, if there has been any important rise in the river-bed resulting therefrom, it should show itself in a corresponding rise in the extreme low-water surface. Several places will be considered, selecting those where our gauge records cover as many years as possible.

(1) *Cairo.*—The lowest water record extends back to 1859, with breaks, but is continuous since 1871. January 1, 1888, the gauge read 1.8 feet, and October 22, 1889, it read 2.7 feet. From November 10, 1859, to these dates the record gives but three dates when the water was as low as in 1888 and 1889. These dates were:

	Feet.
December 26, 1871 (Cairo gauge)	1.0
December 6, 1872 (Cairo gauge)	1.0
January 1, 1877 (Cairo gauge)	1.0

These gauge-readings are lower than those of 1888 and 1889, but the period since 1880 is entirely too short to conclude that in it there was a year in which the discharge reached its lowest value, thus giving extreme low water. The greater low-water heights in 1888 and 1889 may be simply due to there being more water flowing in the river at those times than in 1871. If in seventeen years following 1888 there are no gauge readings as low as those of 1871, 1872, and 1877, it will in some degree indicate, but not prove, that the bed has risen. At present the data do not extend over a period long enough to draw any reliable conclusions.

(2) *Memphis.*—This gauge read:

	Feet.
November 20, 1887	1.20
January 4, 1888	0.80
October 26, 1889	1.90

The records of low water before these dates extend back to 1848, and are continuous back to 1871. The records back to 1848 give but three dates when the water was lower than on January 4, 1888, namely 0.80 foot. These dates are:

	Feet.
December 29, 1871	−0.92
December 25, 1872	−0.95
January 2, 1877	+0.75

Here again the extremely low waters of 1871 and 1872 show themselves, and they are lower than any since 1880. But as was said with reference to Cairo, the period since 1880 is entirely too short to enable us to assume that in it there has been a year of minimum flow, or what amounts to the same thing, that there will not, in a few years, occur a stage as low as that of 1871.

(3) *Helena.*—The low-water record is continuous, excepting 1878 and 1879, back to 1871. The gauge read: December 29, 1871, 1.15 feet.

The record afterwards gives no waters as low as these till 1887. The gauge read:

	Feet.
November 20, 1887	1.20
January 4, 1888	0.80

Comparison of the two periods gives a difference too small to establish a rise of low-water level.

(4) *Lake Providence.*—The low-water record extends back to 1872, and the lowest waters are:

	Feet.
December 29, 1872	−3.85
October 16, 1879	+0.55

Since 1880 the two lowest waters are:

	Feet.
November 22, 1887	1.52
October 31, 1889	2.80

There seems to have been a great depression of low water in this part of the river about 1872. The Terrapin Neck Cut-off, shortening the river about 16 miles, occurred in 1866, and may have been a partial cause. The gauge-readings given indicate a rise in the water surface, and probably of the bed, at Lake Providence since 1872.

(5) *Vicksburg.*—Excepting 1878 and 1879, the low-water record is continuous back to 1872. The gauge read: December 30, 1872, —1.30 feet.

From this date to 1886, the lowest record is: January 6, 1877, 2.25 feet.

Since 1880 we have:

	Feet.
November 16, 1886	0.00
November 24, 1887	—3.91
January 7, 1888	—1.32
October 29, 1889	—0.80

Here the gauge records indicate a fall in the low-water surface, and perhaps a fall in the bed. The question is complicated by the Terrapin Neck Cut-off of 1866 and the Vicksburg Cut-off of 1876.

From 1872 to 1881 the low-water fall in the surface of the river between Lake Providence and Vicksburg varied between 21 feet and 22.9 feet; in 1883 it was 24.9; in 1886, 26.2; in 1887, 29.0; in 1888, 26.7, and in 1889, 27.2 feet. The change of fall from 22.6 feet in 1877 to 29.0 feet in 1887, amounting to 6.4 feet, is very great. About two-thirds appear to be due to a sinking of the low-water plane at Vicksburg, and the rest to a rise in the low-water plane at Lake Providence. The low-water slope from Lake Providence to Vicksburg was in 1884 still much greater than just above or below. Its great value was probably due to the two cut-offs. In 1884 the distance from Lake Providence to Vicksburg was 57 miles; the sum of the two cut-offs was 18 miles. If we suppose that before these two cut-offs the river was two-thirds of this 18 miles longer than now, or the distance from Lake Providence to Vicksburg to have been 69 miles, the slope would have been but fifty-seven-sixty-ninths of its present value. The result of the cut-offs would be to increase the velocity of the river above and near them. This increase of velocity would tend to scour the bed and banks, perhaps making a deposit in the river below the cut-offs and temporarily raising the bed there; and it may be that it is now returning to its normal low-water position by removing the deposits below.

(6) *Red River Landing.*—The low-water record is continuous back to 1872, which was the year of the lowest known low water, the gauge reading 0.0 In 1879 it fell as low as 0.55, and in 1887 to 0.47. The difference in low-water heights of 1872 and 1887 is too small to be evidence of a rise in the bed of the river.

Thus far only low waters of the Mississippi have been considered. The high-water records cover longer periods, but as an increased high water may result from confining the floods between levees as well as from a rise of the bed of the river, it can not be concluded from a rise of flood-heights in the river that the bed has also risen. At Cairo the gauge read:

	Feet.
June 21, 1858	49.6
May 2, 1862	50.8
March 21, 1867	51.0

The river did not again reach these heights till February 26, 1882, 51.87; February 27, 1883, 52.17.

This increase in the later heights is not supposed to indicate any rise of bed, but can be accounted for solely by a greater flood discharge.

At Memphis the record goes back to 1828. In 1862 the river reached a flood height of 34.45, the record then showing no greater one. In 1882 the greatest height was 35.15; in 1887, 35.30, and in 1890, 35.60. This rise of 1.1 feet since 1862 may be accounted for by a greater discharge by the construction of levees below Memphis and perhaps by the influence of railroads across the St. Francis bottom, without the supposition of a rise of bed.

At Vicksburg the record goes back to 1828. The highest known water was 51.1 feet in 1862. The next highest was 49.1, March 15, 1890. Here there is no indication of a rise of bed.

At Natchez the record goes back to 1802. The highest water was 49.9 in 1862. In 1890 the highest water was 48.6 on March 22. In 1815 the highest water was 48.5. There is no indication of a rise of bed.

From the examination of the Po and Rhine it may be concluded that if their beds rise in the leveed portions (which is not entirely certain from the data), it is at so slow a rate as not to be an important factor in the maintenance of a levee system. With levees 10 feet high, if the bed rose at the rate of 1 foot in a hundred years, the cost of raising a line of levees having the length of the present Mississippi system—about 1,300 miles—by this one foot would be but about $4,000,000, distributed over

the country, or $40,000 per annum, which is a small part of the annual cost of the system. On the Mississippi the records, while not extending over a period long enough to give final results, do not, so far as they go, indicate that the bed has risen.

The opinion so often held that levees cause a river-bed to rise is probably due to the fact that the bed of a river does sometimes rise although leveed, and hence it is concluded that the levees cause the rise. Any sedimentary stream, having a definite succession of stages and discharges and flowing in its own alluvion, finally takes such a slope as will give a velocity sufficient to enable it to carry its sediment, whether derived from above or from its own banks and bed, farther down-stream, without, on the whole, scouring or filling its bed. An average velocity less than this will give rise to deposits in its bed, or if it is crooked it will become straight, thus in either case increasing its slope and velocity towards their normal values. An average velocity greater than this will scour its bed, or cause caving in its concave bends, thus increasing its length and diminishing its slope and velocity to such values as its bed can bear without on the whole scouring or filling. When therefore the slope of a sedimentary stream suddenly diminishes from that which it needs for a stable regimen its velocity also diminishes; it drops part of its alluvion, and its bed rises. Thus, when the Mississippi enters the Gulf of Mexico, its slope suddenly diminishes; its velocity diminishes, and it builds up bars out in deep water. So the Adige, where it reaches the low plains of the Po, needs for permanence a steeper slope than the country has, and raises its bed above it. In all these cases the bed would rise without levees.

There is one more cause for the rise of bed of a sedimentary river, which, however, acts at a very slow rate. The Mississippi pushes its mouths out into the Gulf at the rate of about 4 miles in a century, and this increase in length requires a corresponding increase in fall of water surface to make the waters flow out. An increase of 4 miles in length would, with existing slopes, raise the high-water surface at New Orleans about seven-tenths of a foot. The cost of raising levees to correspond with this rise in the water surface would, as has already been seen, be a small part of the annual cost of the system.

C. B. COMSTOCK,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.,
President Miss. River Commission.

NEW YORK, *May* 10, 1890.

Levees on the Hwang-Ho.—The following information, taken from the North China Herald, has been transmitted by the Hon. Charles Denby, United States minister at Peking, to the Secretary of State, and by him to the Mississippi River Commission.

In reference to Mr. Morrison's statement that the bed of the Hwang-Ho is in places higher than the surrounding country, it does not appear that he made measurements except at the break in the levee. There he states that the river was almost at its lowest and that the old river was practically dry. But as the old river below the break may have shoaled up since the break, it does not by any means follow that prior to the break the river was above the surrounding country. The fact that he found below the break on the main river the extraordinary slope of 1 foot per mile also points to a local shoaling immediately below the break, which may have occurred since the break.

C. B. C.

NEW YORK, *May* 16, 1890.

THE YELLOW RIVER.

A meeting of members of the Shanghai Literary and Debating Society was held yesterday evening at the Philharmonic Hall for the purpose of hearing Mr. G. J. Morrison, M. Inst. C. E., read a paper giving an account of a visit to the breach in the embankment of the Yellow River near Chengchow, in September, 1888.

During the summer of 1888 the foreign residents in China were much interested in the accounts received from time to time of the effects of the great breach which had occurred during the previous autumn in the bank of the Yellow River and in the works undertaken to close it. These accounts, however, were of a most conflicting character, both as regards the amount of damage done by the flood-water and the progress of the repairs. At one time it was confidently stated that the works had almost reached a successful termination, at another time that work to the value of some tls.10,000,000 had been entirely washed away, and at another time that very little real work had ever been executed, and that the stories of disasters were invented with a view to conceal the malversations of officials of various ranks.

Along with these reports there appeared from time to time proposals for closing the breach, for keeping the breach open, and conserving the river in its new bed, and for

conserving the river generally. Whatever merit there was in any of these schemes was counterbalanced by the fact that few of them were founded on personal observation by competent persons, and while some of them undoubtedly contained valuable suggestions, they were of such a crude nature that the officials at the breach could easily show that if adopted in the proposed form they would certainly result in failure, and the Chinese Government adopted none of them.

Interviews with H. E. Li Hung-Chang, however, and with other high officials, made it quite clear that an appalling calamity had occurred, that the attempts to repair the damage had been unsuccessful, and that from a state of certainty as to their ability to rebuild the embankment the officials had passed to one of hopes of success, and had finally arrived at a condition where fear of eventual failure was uppermost in the minds of those best able to judge.

Under these circumstances some of the residents in Shanghai began to think it might be worth while to have some definite information as to the state of affairs, and I was commissioned by the Hong-Kong and Shanghai Bank and Messrs. Jardine, Matheson & Co. to visit the breach and report on what I saw.

H. E. Li Hung-Chang expressed himself as being most favorably disposed to my visit, and while not acting on his behalf, I had the advantage of a special passport and a letter requesting the local authorities to give me all the information and assistance in their power.

It was arranged that I should be accompanied by Mr. G. A. Hillier, of the Hong-Kong and Shanghai Bank, and starting from Tientsin on September 14, 1888, we arrived at the breach on the 27th, after fourteen days' continuous cart-traveling from daylight till dark.

Before saying anything regarding the breach it will be convenient to make a few remarks on the Yellow River generally.

All residents on the coast of the northern portion of China are acquainted with the way in which the land gradually extends seaward. The immense amount of silt brought down by the Yangtze, the Yellow River, the Peiho, etc., and other less important streams is deposited near their mouths. As this land grows, the inhabitants gradually bring it under cultivation. Being very low, it is constantly exposed to floods, and one of the first works of the farmer is to build a small embankment along the most exposed places. The streams, being subject to floods from inland waters, rise higher than the tides, and embankments along these become of vital importance. As the extension of land proceeds population increases, and possession is taken of the ground on the river side of these embankments, outer embankments being constructed so as to protect this newly reclaimed land from floods, and this work goes on on both sides of the river until the channel is contained between two embankments only sufficiently far apart to allow the water to pass in times of flood; any attempt to encroach further on the river being sure to end in failure.

I do not for a moment maintain that the Yellow River has deposited the great plain of China during the life-time of the human race, nor do I even wish to raise the question of the origin of the main portion of the great plain at all, but what I wish to make clear is that ages ago the population found a river divided probably into several streams, that they gradually built embankments one after another to protect their fields against floods, until at last they confined this immense river between two more or less substantial embankments, and that it is with this river thus artificially controlled that we have to deal, and not a river wholly or even in great part existing under natural conditions. One of the first effects of such embankments is to raise the level of the high floods. An amount of water which will flood an area 50 miles wide 2 feet deep is sufficient to flood a width of 5 miles 20 feet deep; and though no such simple proportion exists in reality, still it must be clear that as soon as the width of the flood channel is decreased the depth of the floods increases, and the final embankments must therefore be much higher than the first protecting banks.

Between these embankments thus the river flows usually in a comparatively narrow channel, but in times of flood it extends to the embankments, rises above the level of the surrounding country, and when it finds a weak spot breaks through and floods the adjacent lands. It was a calamity of this sort which occurred last year in Shantung, but, under the conditions referred to above, such an inundation, however appalling, can be only temporary. In a few weeks or months, as the case may be, the river falls, the flood waters drain off, and the embankment can be repaired. It may be and often is worth while to try to stop breaches of this sort even before the subsidence of the flood, but it must be clear that the closing of such a breach need never baffle human ingenuity. The time is sure to come when the work will be simply that of making a river embankment.

As time goes on, however, quite another state of affairs comes into existence. If the embankments are kept intact each flood leaves a certain amount of deposit. This is most marked near the embankments where the water is shallow and the speed of the current less than in the center, but it tells by degrees even on the low-water channel itself; and after a time it is no longer the surface of the flood-water

that is higher than the surrounding country, but the very bottom of the low-water channel becomes higher than the land outside the banks. How long it takes for this state of affairs to be brought about I do not pretend to say without much more information than is possessed at present, but this may be safely stated, that all raising of the bottom of the low-water channel above the general level of the country has taken place since the river was confined between artificial embankments. Of the extent to which this raising has taken place I shall speak further on, but it does exist along a considerable portion of the present bed and of the old bed which it occupied until about forty years ago, and which now goes by the name of Yu Huang Ho or Silted Yellow River, showing that the Chinese are well aware of the fact.

Under such conditions as these a breach of the embankment resembles such a breach as I have before described, in name only. No matter how low the water may fall it will continue to pour out of the bed into the country; and when it is remembered that the Yellow River is one of the great rivers of the world it is seen that the closing of such a breach is beset with difficulties such as have rarely if ever to be encountered during the execution of the most extensive engineering works of modern times.

In the maps which many of us used at school, the Yellow River was shown (and correctly shown) as entering the Yellow Sea south of the province of Shantung, crossing the Grand Canal at a place called Chingkiangpoo (not to be confounded with Chinkiang on the Yantze). Early in the fifties, however, it was noticed that the color of the Yellow Sea had considerably altered, and I believe it was Dr. Macgowan who first brought to the notice of residents here the fact that there was abundance of evidence that the river had changed its course and was now flowing into the Gulf of Pechili.

In 1868 Mr. Ney Elias visited the river and made a map of the new course, from which it appears that at a place called Lungmênkow, some 10 miles east of Kaifongfu, the river had burst through its northern embankment and, flooding the adjacent country, had eventually found its way to a small stream called the Tatsing and had taken possession of its bed, carrying away bridges and other obstructions, and, passing a few miles west of Tsinanfu, the capital of Shantung, was flowing into the Gulf of Pechili at a place named Tiehmênkow. In its course it crossed the Grand Canal at a place called Pahlimiao and at the time of Mr. Ney Elias's visit the portion of the river between the breach and the canal was in a deplorable condition. Any attempts that may have been made to close the breach must have entirely failed, and between the points above mentioned a tract of country some 20 miles wide was practically given up to the river. Below Pahlimiao the river, following a bed below the level of the country, was well defined.

When I visited this place in 1878 great changes had been effected in the upper portion. Close to the breach, it is true, the scene was still one of the utmost desolation. The river consisted of a net work of channels where deep holes were followed by shallows of such slight depths that my boat, drawing a little more than a foot of water was often aground, on two or three occasions for hours at a time, while the banks of the river were unrecognizable and probably really out of sight. After about twenty miles, however, there was a great change for the better; the officials had been at work, and the immense marsh intersected by channels of various sizes had given way to a river confined to one low-water channel, and with embankments along both sides at a moderate distance, apparently just sufficiently wide apart to take the flood waters.

Below Pahlimiao as far as Tsinanfu the river was in precisely the same condition as at the time of Mr. Ney Elias's visit. Of the lowest portion of all I cannot speak, as I have never seen it.

It appears, therefore, that as soon as the officials discovered that they could not close the breach they set about conserving the new channel. The portion between the canal and Tsinanfu presented no difficulties, but the upper portion was little but a marsh and had to be converted into a river by the construction of embankments, and, as giving some idea of the time occupied by such works, the length between the breach and the Grand Canal measuring about 100 miles had been nearly but not quite brought under control in some twenty-five years after the breach had occurred.

The whole of the new course from the great breach at Lungmênkow above referred to appears to be below the general level of the country immediately adjacent to the river, and there is therefore fair reason to suppose that, if moderate care be taken to protect the embankments, any floods arising from breaches along this part of the course will be for many years to come only temporary, and the river will stick to its present bed. In course of time, however, the process of silting will gradually raise the bed and the officials will go on raising the embankments. At last some day a breach will occur which the officials cannot cope with, and the present course will be left high and dry, and a new tract of country will be flooded, the officials will again control the river between embankments, and the silting will take place as usual and eventually bring about another catastrophe. These things have happened more than

once in historic times, villages still existing which derive their names from having been on the banks of the Yellow River, and the traveler in these districts very soon understands why the river has been called China's Sorrow.

The Yellow River appears to have a great fall as it flows through Shansi, its height above the sea at the northern point of Shansi being about 3,500 feet and at the southern point where it enters Honan probably not more than 500 feet. It consequently enters Honan charged with silt, and, its velocity being checked, immediately begins to deposit it. The heavier particles are deposited first and the silt found in the northwestern part of Honan, as evidenced by the bed of the river, by the remains of a channel formed after a breach about a century ago, and by the embankments which are made from the bed of the river, is pure sand, so clean that when a quantity is rubbed between the hands it leaves not the slightest stain. Further down, however, there is a more muddy deposit, and the old bed, which runs past Chingkiangpoo, is now cultivated and is exceedingly fertile. As most silt is brought down during floods the portions of the bed between the low-water channel and the embankments are quickly raised. The low-water channel alters its position from time to time and when it keeps for a long time cutting towards one embankment, the land which it leaves between it and the other embankment soon rises to nearly the level of the highest floods and is covered only at intervals of many years. This land is then brought under cultivation and a comparatively low embankment suffices to protect it against occasional floods. On the other side of the river, however, the safety of the embankment is soon threatened, the officials begin to strengthen and protect it and if at last they find the river too strong for them they build another embankment outside and let the old one go. In this way one often finds several embankments parallel to the river, but one which has been built in a silted bed is easily distinguished from an original embankment which separates the bed from the ordinary country. The former of these has the land on both sides approximately level; not so the latter, *i. e.*, the original bank. The appearance of the first of these banks which are seen by a traveler is most surprising. Going along through the country he sees something like a railway embankment 30 or 35 feet high. On reaching it he ascends and finds the top as a rule from 30 to 60 feet wide, but on looking down on the inside he finds the bed only 15 or 20 feet below him. He can hardly help thinking that the country is the bed and that the bed is the country, but he soon realizes the fact that when the embankment was constructed the land on both sides was probably about the same level, but years of silting had raised the bed far above the country. While, however, the general appearance, particularly in the case of the old and disused bed, leads one at first to think that the general level of it is from 12 to 20 feet above the country, measurements show that it is only at the edges that the bed is so high, and that the lowest portion of the bed is probably not more than 5 or 6 feet above the general level of the land outside.

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Having thus given a general description of the Yellow River, I may proceed to give some details of the great breach of 1887. The town of Chengchow, near which it occurred, lies some 40 miles west of Kaifongfu, and the river at this point flows in its old bed, the great breach of 1854 having occurred some 50 miles lower down. The embankments here are constructed of little but sand, and the river has for many years been cutting away its southern shore, the northern embankment having been left many miles to the north. The low-water channel runs for a long distance close to the southern embankment, while its bottom is 4 or 5 feet above the level of the country outside. In the autumn of 1887 the appearance of the river became very threatening, and despite the utmost efforts of the officials to protect the embankment against the effects of the current, it was gradually eaten into. Towards the end of September water began to trickle through in several places, and on the 29th of September, 1887, a portion of the embankment gave way.

As soon as the water began to run through the opening the embankment was quickly carried off by the flood, and in a very short time no less than a mile of it had entirely disappeared. Through this gigantic opening the entire river flowed out quickly, eating down its own bed close to the gap to the level of the country outside, and before very long the old bed of the river below the gap was left perfectly dry.

The water which came through the gap, that is to say, the whole of the water of the Yellow River, flooded an immense track of country. There being no valleys along which water would naturally run, it seems to have spread itself over such a large area that there was very considerable difficulty in saying what was the direction of the main stream. Probably the principal portion of the water found its way towards the Hungtse Lake, the level of which was considerably raised. Thence a large portion flowed through the Kao Yao Lake and along the low-lying land bordering the Grand Canal to the Yangtze, while a considerable portion passed into the Grand Canal and was thence directed as far as possible through the numerous sluices in the eastern bank towards the Yellow Sea. The amount of damage done by this flood is not very well known Numerous villages were swept away and some cities suffered

considerably, one having been saved only by the populace looting the pawn shops and filling up the gateways and other openings in the walls with clothes, and so protecting the interior from being ruined by the first rush of the torrent. Still, after the first news of the disaster, the subsequent reports were of a much less distressing nature than was expected. It is probably the case that the area flooded was so wide that the average depth did not exceed a very few feet, and as in even the flattest country there are differences of level of a foot or two, large portions of every district must have been left uncovered, while further portions could be reclaimed with scarcely any trouble. In this case the distress would rather be wide-spread than acute, and though the suggestion is not founded on direct evidence, there is good reason to believe that it nearly represents the actual state of affairs.

Under these circumstances there were two courses open to the Government. One was to close the breach and bring the river back to its old course, the other was to leave the breach untouched, to make a new channel for the Yellow River towards either the Yangtze or the Yellow Sea, leaving the old bed to be cultivated in certain portions, and probably to form lakes in other places. The idea that the river must have picked out the best course for itself may at once be dismissed. It has been flowing in a raised bed, that is to say under entirely artificial conditions, and had broken through at one point and flooded the country. It broke through not because the general lay of the country was favorable to it, but because the artificial bank happened to be weak at that point. There might be, and I believe there was, a very much better course on the north side of the old river, but the water having once dropped down on the southern side was prevented by the old artificial course from ever again finding its way north. While, however, there is no possible excuse for saying that the river had found the best course possible, it is true that if confined between embankments it would have been constrained to follow a course probably a few feet lower than the adjacent country, which would be a much better channel than the one it left; but then it must be remembered that the old high-level channel continued for only about 50 miles below the breach, viz, to Lungmênkow, where the old breach of 1854 occurred, below which point the river followed a channel at least as good as, and I believe considerably better than any that could be picked out for it to the south, and one on which moreover the officials had been at work with more or less activity for more than thirty-five years, and which in any case is better now than the new channel to the south could be made in thirty-five years more by the construction of some 800 miles of heavy embankments, to say nothing of the temporary works. I believe then that the Chinese officials were fully justified in determining to close the breach and restore the river to its course if they could.

The system which the Chinese authorities adopted of closing the breach was in one sense the simplest possible. Finding that a mile of their embankment had been cut away they started at each end of the old embankment and carried forward new ones to meet near the middle of the breach. The water as before stated had flooded all the country for miles in every direction outside the breach, but a small embankment of a few feet in height was run out from the western end of the breach approximately at right angles to the river and this protected the land to the westward, but all the land to the south and east remained flooded as far as the eye could reach, one of the principal streams running close along the outside of the eastern embankment with a depth of 10 or 12 feet.

It is evident that if the authorities had simply constructed their embankment of sand it would have been washed away as fast as they made it, and they therefore constructed it of bundles of millet stalks fastened together with ropes and stakes and filled in with mud, if they could get it, but generally with sand, and loaded with stone.

As before stated the old embankments are from 30 to 60 feet wide on top, but the officials rightly judged that such a width would be too small for their new bank, which they therefore built much wider, but most people will be surprised to hear that the width varied from 250 to 350 feet and the average was fully 300 feet. The stalks of the Kaoliang or large millet are neither strong nor lasting, and in most respects are much inferior to willows, or osiers, generally used in Europe, but they are yielding, and as each layer is weighted by the layer on top the mass is crushed together and the sand is retained so that the embankment becomes impervious to water; while if osiers are used the sand gets washed away and the embankment is little better than a sieve, and I soon became convinced that for the purpose in this special case no better material could be used. The means of obtaining materials and labor was simplicity itself. Notices were put up that millet stalks would be bought at the works at a certain price, which varied at different seasons, and I saw one proclamation stating that all delivered before a certain day would be paid for at the rate of Tls. 0. 0. 2 per catty, or say a half penny a pound, and I saw millet stalks being carried to the works in barrows; so the immense quantities required appear to have been collected in very small lots. As the millet stalks arrived they were tied in bundles and built in stacks. When required for the works the coolies went to the

stacks, each man received a bundle, and proceeded to the embankment, where, on passing through a wicket gate, he received a stated number of cash. As regards sand it appears that the men could go for it where they liked, and on bringing a barrow load to the works each man on passing a wicket received 30 cash if his barrow was considered full.

On this system work no doubt went on easily enough at first, but it will be readily understood that as the two ends approached each other the speed of the current increased, with the natural result that the bottom was eaten away. The lowering of the masses of millet stalks at the ends of the embankment became a work of some difficulty. The method adopted was generally as follows: A large boat was anchored near the end of the embankment and ropes were let down the embankment and laid over the boat. On these ropes masses of millet stalks were placed, the bundles being secured together by ropes and stakes filled in with stones and sand, and this mass was eventually lowered between the boat and the embankment, the ropes from the boat being eventually brought over the mass and fastened back to the end of the bank by stakes. When a certain number of these masses had been laid so as to come above water-level, the whole was built up as high above water as was thought necessary.

Probably ignorance of the almost superhuman exertions that would be required to construct the final length formed a great element in the enthusiasm of the officials, and they are perhaps hardly to be blamed if, when the original width of 5,300 feet had been reduced to 500 or 600, as must have been the case in the summer of 1888, they spoke of the completion of the work as being near at hand; but they were doomed to disappointment. The summer floods treated them very badly, not only by washing away some portions of their work, but by scouring out the breach to an almost incredible depth. It seems to have been about this time that the higher officials began to get alarmed. They began to realize the fact that the work before them was of a gigantic character. The amount of the embankment swept away was not very large compared with the whole work executed, but to replace it was far more difficult than the original work of construction. The current was gradually eating away below the new embankment and was threatening to undermine it entirely.

It is greatly to the credit of the local officials that they did not lose heart. They cast in immense quantities of stone brought from quarries about two days' sail up the river, and where portions of the embankment sunk they added fresh material on top, thus adding weight to the whole structure, and so preserved the bulk of their work until the falling of the water gave them breathing time.

When I arrived at the breach in September the ends of the two embankments were within 400 feet of each other, measured at the top. They were, as I have previously said, about 300 feet wide, and at the ends they were about 40 feet above water, this height being given partly in order to add weight to the lower portion and prevent its being carried away, and partly to facilitate the building of masses of fascines to lower into the water; but the great feature was the depth of water, which was 70 feet.

The speed of the current was not very great. Boats passed down from time to time, but seeing that the breach was full of eddies of such extent that sometimes boats were carried right up on the west side, no proper measurement could be made. Judging from the appearance of the boats going down, I estimated the velocity at seven miles an hour.

Practically the whole of the work up to this point had been done by Li Hung-tsao, who had been long in charge, but had just been sent for to Peking, and who had been replaced by Wu Ta-chêng, who took charge a short time before my arrival.

The bed of the river below the breach was practically dry. A small canal had been cut along it to relieve the breach of some of the water, but it was so small and so poorly executed that for practical purposes it may be disregarded, and the level of the water flowing through the breach was distinctly lower than the old bed. Very careful leveling showed that the lowest part of the old bed just below the breach was 18 inches higher than the surface of the flood water outside the bank, and as the average depth of this was certainly over 2 feet 6 inches, the bottom of the river was at least 10 feet above the average level of the country, and as the depth in these places where the flood waters were flowing quickly was about 10 feet, or more, it may safely be said that the bottoms of the ordinary water courses in this district were some 12 feet lower than the bottom of the Yellow River.

Mr. Hillier had some long interviews with Wu Ta-chêng, who, from the first, expressed himself as being confident of success, but it is not surprising that many people took a less hopeful view. I found that all the European engineers who had expressed any opinion on the subject had stated their belief that the Chinese could never close the breach by simply advancing the two ends to meet, and those who had examined the place most carefully were most decided in their opinions.

On my arrival I at once proceeded to make a general survey of the place and to take some levels, and after I had by these means made myself acquainted with the leading facts of the case I began to consider more closely the possibility of the Chinese

being successful, and on the other hand to put into practical shape some scheme for closing the breach should the Chinese fail. The only fact of great importance which I have not already stated is that the fall of the bed of the river immediately below the breach is as nearly as possible one foot per mile. This is a very great fall for such a large river, but the result was arrived at by careful leveling, and is undoubtedly correct for a very considerable distance. This fact has an important bearing on the possibility of cutting a channel along the old bed so large and so deep as to draw away the water from the breach. It will be seen that the construction of such a channel would be possible, but would be a very large work, and the Chinese proposal to construct one 15 feet deep and 1 mile long under the impression that once the water was let into it it would rush down and carry everything before it, clearing out a channel for itself, seemed to me so utterly unpractical that I gave it no further thought and I turned my attention solely to the breach. It was clear that by simply crowding on men and employing materials in the most lavish manner the Chinese had constructed two immense and most substantial embankments, fully able to do their part of the work if the gap was closed, but the most important point was that the breach had been scoured by a most severe flood much greater than any that might be expected for several months. This flood must have undermined the ends of the embankments which sank and was made up on top, but which must have slipped out a considerable distance towards each other at the bottom. The water, when I saw it, was almost at its lowest, and would probably remain like that for three months; and it appeared to me that the gap might be considerably narrowed before the velocity became as high as it had been during summer, and till this occurred probably no further scouring would take place; and I thought it well within the bounds of possibility that fully 100 feet could be added to each embankment in somewhat the same manner as the first part had been made. By that time the tops of the embankments would be within 200 feet of each other, their bottoms would certainly touch, and it seemed possible that by making a regular network of ropes over the breach, a mass of millet stalks and sand could be made of such a size and of such strength that when lowered into the breach the current could not carry it away. If this were done the interstices could be filled up with smaller masses and eventually the breach could be closed. I therefore represented to H. E. Wu Ta-chêng and to H. E. Li Hung-chang that in my opinion they should strain every nerve to proceed with the work in the ordinary manner, and not until the next flood overpowered them should they think of European systems, and there was, as I put it, an even chance in my opinion that they would be successful. This opinion proved to be correct, and on the 20th of January, 1889, the breach was finally closed, the immense depth of water in which this was effected being evidenced by the fact that there is a lake immediately outside 50 feet deep.

That the Chinese did right in making up their minds to close the breach, if possible, I have not the slightest doubt. There are many places where the river embankments are very bad, notably in the neighborhood of the late breach, but there are hundreds of miles of fairly good embankments, or at least of embankments as good as any others that could be built along a new course during the next twenty or thirty years.

Some of the latest instructions which have been given regarding the mouth of the river show that the authorities are learning either from experience or from good advisers something of the right of way of dealing with such rivers. When the Chinese have in former years been troubled with floods in their rivers they have been too ready to cut extra channels to carry off the surplus water. This as a rule is the exact opposite of what should be done. The extra channel lowers the velocity, the river deposits more silt, the bed rises, and the level of the floods becomes higher than ever. The last instructions appear to be to close all the mouths of the river but one. This one the river must keep open, and its increased velocity will deepen the bed and probably lower the level of the flood-waters of the river.

I am by no means of opinion that the Chinese have mastered the science of river engineering, nor that even when good orders are given the work will always be carried out in a satisfactory manner; but I am perfectly certain that they can deal with the Yellow River better than any foreigner who has to base his opinion on the results of a cursory visit and such general information as he can pick up from notices scattered through books and periodicals, and if I hazard any opinion it will be to the effect that there is no radical cure for the troubles of the Yellow River. A board of conservancy might do much to keep the river works in such a state as to prevent the inundations that continually take place, but all hopes of inventing any scheme which will set matters to rights once for all is entirely chimerical.

In reply to a question as to what had been the result of closing the breach, Mr. Morrison said the river was now flowing in its bed.

The Rev. T. R. Stevenson, in moving a vote of thanks to the lecturer, said they had heard a most lucid explanation of one of the most interesting catastrophes of modern times.

The Rev. Dr. Edkins, in seconding, said: We are very much indebted to Mr. Morrison for the account he has given us of the Yellow River, and for his extremely graphic and interesting description of the breach and the way in which it has been closed up. It seems to me we see here what Chinese can do; and one principal reason why they are able to attack a problem is because of the great past behind them. It is not the first century in which they have undertaken great engineering works. It is very interesting to read in old Chinese literature of the way in which from time to time they have met the catastrophes of their rivers; and there is one especially interesting account in the history of the first century before Christ, in the reign of the Emperor Han Wu Ti, one of the great names of Chinese history. He visited the works himself. He was an eminent conquerer, and surrounded by nobles, statesmen, and men eminent in literature; and one interesting circumstance is that he himself wrote a poem which has been preserved ever since in Chinese literature, describing the breach and the work that was being done in filling it up. The point at which this took place is not very far from Chengchow, which the lecturer has himself visited. At that time China was a different country from what it is now. Instead of the kao-liang stalks, of which you have heard, they were able to collect considerable quantities of bamboos. Naturally this would render the work easier to accomplish, and would give greater power of resistance. There are many interesting circumstances which I will not attempt to enter into now, but I feel a very considerable gratification in thinking that the Chinese in maintaining their power of engineering to this extent show the effects of the history of the past upon them; and the knowledge and energy they are able now to exhibit is on account of the knowledge and energy which their forefathers acquired and exhibited before them. Considering the decided opinion that has been formed by the lecturer in regard to the success of the Chinese, and the decided approval he has given to the course they took to fill up the breach, I think we should have a great amount of satisfaction in the thought that the Chinese are not so incompetent as many men represent them to be, and that not only in river engineering, but in many other subjects that come before the statesmen of this country they are not so unprepared as many men suppose to meet their difficulties and turn their catastrophes into exhibitions of great energy. Upon the whole the result is that we should add something to our opinion in regard to the power and the competency of the Chinese to meet their difficulties.

APPENDIX B.

MEMORANDUM ON OUTLETS.

Outlets have often been proposed as a method of reducing flood heights on the Mississippi. The immediate results on flood heights are so evident and so beneficial when a large crevasse is formed, the good results of an opening far larger than ever occurs naturally seem so immediate and apparent, that it is not strange that many persons look on them as the true remedy for great floods.

In a letter of February 1, 1890, to the Chief of Engineers (extract appended hereto), I considered the effects of making an outlet a mile wide and to a depth of 10 feet below low water, from the Mississippi River into Lake Borgne, and need not repeat the discussion here. In it I assumed what is well known to all persons familiar with hydraulics, namely, that a sedimentary river flowing in its own alluvion only acquires a stable regimen when it has taken a slope suitable to its varying discharges and to the material through which it flows; and, as a rule, that these slopes diminish as the size of the river increases, and increase as the size of the river decreases. It may be well to give some examples of this general fact.

(*a*) The South Pass carried, in 1875, about one-fourth of the water that the Southwest Pass did. Its slope, from the head of the Passes to its original bar, was about one-third greater than that of the Southwest Pass.

(*b*) The observed discharges of the Atchafalaya in 1882 were from one-seventh to one-tenth of those of the Mississippi. Its average slope to the Gulf is double that of the Mississippi.

(*c*) The Salina Pass, in the Delta of the Danube, carries two twenty-sevenths of the total river flow, while the St. George Pass carries eight twenty-sevenths. The slope of the Salina is one-half greater than that of the St. George Pass.

These examples are sufficient to illustrate the general rule already stated, that sedimentary rivers flowing in their own alluvion take larger slopes the smaller they are. Hence, if at Lake Borgne or elsewhere in its Delta, the Mississippi were divided into two rivers, since each would be smaller than the present river, the two new rivers would go to work to obtain the new and steeper slopes suited to dimensions

smaller than those of the original river, and hence would build up their beds. This process would only cease when the steeper slopes needed by each were obtained. Since both rivers would then have one end at the gulf, and have steeper slopes up to their point of divergence than the main river now has, the flood surface of the river at that point would be higher than now.

There have been cases where the experiment of dividing rivers in two has been tried by nature or by man. About A. D. 1438, the Adige broke its levees and poured its waters south into the Castagnoro and Canale Bianco, which then formed a drainage stream parallel to the Po. In 1545 the break had so increased that two-thirds of the low-water flow of the Adige and three-fourths of the high-water flow went through it. A low dam was built across the Castagnoro, to check the flow into it, and both rivers raised their beds. In 1678 a new dam was built, as the old one was then buried in the deposit. The bed still rose. In 1791 a masonry dam 39 feet high, with many archways through it to allow floods to pass, was built across the Castagnoro. The bed continued to rise and the floods on the Adige were so high that in 1838 the Castagnoro was permanently closed. In the six years following the closure the floods in the Adige fell, and the more markedly the nearer the point considered was to the Castagnoro.

Thus far only outlets have been considered which are permanent rivers. For such outlets the effect in finally raising the flood surface of the main river will be the greater as the flow of the outlet is more nearly equal to the remaining flow in the main river. If the outlet is small its effect on the main river will be small.

Places at which there is no escape, except at high stages, are sometimes called outlets. For many years prior to the recent closing of the levee gaps along the Mississippi, below Red River, and of the gaps which permitted water to escape from the vicinity of Turnbulls Island into the Atchafalaya Basin, the maximum flood flow past New Orleans was but about 1,100,000 cubic feet per second. This flow is ample for all navigation purposes, and no practical gain to navigation will result from increasing it. In 1882 it was estimated that about 2,200,000 cubic feet per second passed the latitude of Red River mouth. It has been proposed to allow only 200,000 cubic feet per second to go down the Atchafalaya, leaving 1,900,000 or 2,000,000 cubic feet per second to go down the main river. In my judgment, until the heights of levees below Red River are largely increased, there should be left a free opportunity for the escape overland of 400,000 cubic feet per second from the vicinity of Turnbulls Island into the Atchafalaya Basin, in such floods as that of 1882, in addition to the 200,000 cubic feet per second which is to go down the Atchafalaya. If such an escape, existing only at high water, be called an outlet, then I think it necessary, at least for the present. It will do no harm to navigation, which was good enough for many years before the escape into the Atchafalaya Basin was reduced. On the other hand, to try to force, in a great flood, 1,900,000 cubic feet per second past New Orleans, with levees at present heights, is sure to renew the disasters to levees at or below Red River which have occurred this year. The injury resulting from many breaks below Red River is so much greater than that resulting from the escape into the Atchafalaya Basin, from the vicinity of Turnbulls Island, that the lesser interests should yield to the greater until it is possible to protect both.

It may be concluded that the reduction, by any large amount, of the flow of the Mississippi at Lake Borgne will be ultimately followed by a rise in the flood heights at that place and a shoaling of the river below and at its mouth.

Also, that until levees below Red River are much higher than they are now, about 600,000 cubic feet per second in the greatest floods should be allowed to go into the Atchafalaya Basin, thus relieving the river below.

C. B. COMSTOCK,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.,
President Mississippi River Commission.

NEW YORK, *May* 10, 1890.

[Extract from a letter to the Chief of Engineers, February 1, 1890.]

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The Lake Borgne Outlet.—A canal a mile in width leading from the Mississippi into Lake Borgne, its bottom being everywhere 10 feet below low water, as proposed by the bill, would, by an approximate computation, which is the only one practicable in such a case, divert from the Mississippi about 400,000 cubic feet per second when the stage of the river near Lake Borgne is about 7 feet above Gulf level, and 500,000 cubic feet when the stage there is about 9 feet. The corresponding stages at Carrollton would be about 10 and 12 feet (since the slope would at last be the present high-water slope), the maximum stage there being 15.6 feet above mean Gulf. An outlet diverting 400,000 cubic feet per second would lower the highest flood at Carrollton by about 6 feet. (These computations are based on the discharge curve at Carrollton of 1883.

If more water is forced past Carrollton hereafter by maintaining levees above, these figures will need modification.)

Judging from the effect of local changes of flood height elsewhere on the river, this lowering of flood height at Carrollton would die out in something like 200 miles in ascending the river. Since for this distance the slopes would be steepened, it follows that velocities would be increased, with their destructive effects on the banks of the river and on levees. The outlet would do no good to navigation, but rather the reverse. The first effect of taking 400,000 cubic feet per second out of the Mississippi would be a large lowering of the flood surface near the outlet. The flow through Lake Borgne would itself be a river of large size.

Both theory and experience show that when, at all stages, a reduction in the size of a river flowing in alluvial soil is made, or the river is split in two, the smaller rivers gradually take greater slopes than the main river had. Hence both the main river and the new river would gradually increase their slopes to suit the new conditions. Since the slope begins at the Gulf, it can not become greater on the main river below Lake Borgne, which is now nearly straight, without increasing flood heights at Lake Borgne. After some years, then, if both routes to the sea remained large rivers, the flood level above the outlet would be higher than it is now, unless, as indeed is not improbable, the large amount of sediment which would be dropped into Lake Borgne (where the flood velocities would at first be but about one-sixth of those in the Mississippi) should close this outlet, thus repairing the injury done to the main river. A large diversion of flow from the Mississippi to Lake Borgne would also seriously diminish the depths at the present mouths of the river.

For the following reasons, then, no important outlet at Lake Borgne should be either undertaken or permitted:

(1) It would for some years lower the floods at the outlet, accelerate velocities above it, and increase caving and the consequent destruction of levees.

(2) It would cause shoaling at the present mouths of the river.

(3) If both the new outlet and the main river below it remained important streams—that is, if neither of them closed itself under the action of natural causes—the flood heights at Lake Borgne and New Orleans would after some years be greater than they are now.

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APPENDIX C.

NOTE ON FLOOD REPORT FOR 1890.

The reports of the district officers on the flood of 1890 contain a large amount of valuable information. Two of them, those of Captains Kingman and Leach, contain some conclusions which have a very important bearing on the heights needed for levees. If the conclusions are not justified they should not pass without notice.

(1) Captain Kingman takes the discharge of the Nita Crevasse on May 7, 1890, as 402,000 cubic feet per second, and says:

"At that time it became equal to one-third the entire discharge of the river. Notwithstanding this enormous escape, however, through the outlet, the actual fall directly traceable to this crevasse of the gauge at College Point from its highest point was only about 1.9 feet."

This conclusion is largely in error, as will now be shown. It is necessary, however, first to say that errors of 5 per cent. are common in the gaugings of the main river when carefully and deliberately made, and hence that conclusions based on them are only approximate. In the gauging of crevasses, where the motion of the water is very irregular on account of the variations in cross-section of the crevasse channel, and where the observations are made hurriedly and under the danger of the observer's boat being carried into the crevasse by the high velocity, far greater errors must be expected, possibly amounting to one-third of the measured discharge. Whenever possible they should be checked by other determinations.

In attempting to determine the effect of a crevasse with a given discharge in lowering the water surface from the position it would have were there no crevasse, the simplest case would be that in which, at some gauge far enough above the crevasse not to be affected by it, the river height remained stationary during the whole time considered. In that case the whole lowering of the surface at the crevasse could be attributed to the crevasse. Should the river, however, be rising at the upper station this must be allowed for in estimating the effect of the crevasse. Should the river rise fast enough at the upper station to more than balance the increase of escape at the crevasse then the river surface might even rise at the crevasse, thus apparently showing a rise as the result of a crevasse, although the real effect is of course a fall

from what the water-surface would have been without the crevasse. Apparently overlooking this Captain Kingman's results are unreliable.

The observed discharge of the Nita Crevasse on March 23, 1890, was 89,000 cubic feet per second. On May 8, 1890, it was 402,000 cubic feet per second. The break occurred on March 14. Assume, in the absence of other information, that between these dates the discharge varied directly as the time, and interpolate for intermediate dates accordingly. An examination of the curves of water heights for stations above the crevasse will show that, while the crevasse affected river heights above as far as Bayou Sara, it affected the Red River Landing gauge height slightly or not at all. The Red River Landing gauge will then be taken for comparison with the College Point gauge to determine the effect of the crevasse on the water-surface at College Point.

From March 16 to March 31 the Red River Landing gauge was practically stationary, varying but 0.2 feet. In this time the College Point gauge fell 1.5 feet, and this fall was mainly due to the Nita crevasse, the Lafourche discharge changing very little. By interpolating as mentioned above, the discharge of the Nita crevasse on March 31 is found to be 141,000 cubic feet per second, which caused the lowering of 1.5 feet. From March 31 to April 21 the Red River Landing gauge rose 3.4 feet, nearly to its maximum, and then began to fall in consequence of the breaks below between April 21 and 23. Without crevasses this rise of 3.4 feet at Red River Landing would have given a rise at College Point, between April 1 and April 22, of about 1.8 feet. But the College Point gauge reading, instead of increasing by this amount, decreased by 0.1 foot; so that, as the Nita crevasse and the Bayou Lafourche were the only escapes during this time, and as the total escape at Bayou Lafourche was but about 40,000 cubic feet, the change in its escape (being that due to a change of gauge reading of but about a foot) was also small, and the reduction between April 1 and April 21 of the reading of the College Point gauge by 1.9 feet below what it would have been if the Nita discharge had remained the same as on March 31 was due almost entirely to the increase of the Nita discharge. Interpolating as before, for the discharge on April 21 we obtain 286,000 cubic feet per second, an increase of 145,000 cubic feet over that found for March 31. The fall at the College Point gauge of 1.9 feet, between March 31 and April 21, below its reading if the escape had not increased, is due to this increase of 145,000 cubic feet per second in the escape.

Hence, summing the effects of the Nita crevasse, it lowered the water surface from what it would otherwise have been:

	Feet.
Between March 16 and March 31	1.5
Between March 31 and April 21	1.9
In all, up to April 21	3.4

the escape on April 21, which caused this lowering, being 286,000 cubic feet per second. This result differs very widely from Captain Kingman's estimate of a lowering of 1.9 feet by an escape of 402,000 cubic feet per second.

As the maximum gauge reading at College Point, 5 miles below the Nita crevasse, was reached on April 22, the discharge of the crevasse doubtless increased after this date, and gave rise to a lowering of the water surface which, to obtain the full amount, must be added to the 3.4 feet already obtained. But several other breaks occurred from April 21 to April 23, between Red River and College Point, and the further effect of the Nita crevasse in lowering the water surface at College Point after April 22 can not be separated from that of the other breaks.

A lowering of water surface of 3.4 by an escape of 286,000 cubic feet per second would correspond to a lowering of 1 foot by an escape of 84,000 cubic feet; but, owing to the uncertainties in crevasse measurements, this can only be considered as an approximation to the truth.

(2) Captain Leach, from discharge measurements given in his report, concludes first, that the maximum discharge over the parallel of Memphis, in the flood of 1890, was 1,835,000 cubic feet per second, and that in 1882 it was 1,799,000 cubic feet per second, and hence that the maximum flow past the latitude of Memphis was greater in 1890 than in 1882 by 36,000 cubic feet, while it was less at Helena in 1890 than in 1882 by 231,000 cubic feet—a change in the difference of flow of 267,000 cubic feet per second; second, he attributes this change to the fact that in 1890 the whole flow at Helena was confined between levees; hence he conditionally concludes, third, that the maximum discharge of a given flood, when confined by levees, will be "but little greater than the maximum discharge in the channel of the same flood unrestrained," that is, not confined by levees.

These conclusions have so direct and important a bearing on the height needed for levees, and make the levee question one so simple that, if true, the plan of the Commission should at once conform to them. If not true, they are very misleading. The conclusions will be examined in order.

(1) The following table shows the relation of the flood height of 1890 to those of 1882 and 1883, respectively, from Memphis to Cairo:

	1890, above.		1890, below.	
	1882.	1883.	1882.	1883.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Memphis	0.4	0.8	.....	.....
Fulton	.....	.....	1.8	1.4
Cottonwood	.....	.....	1.2	1.6
New Madrid	.....	.....	3.1	3.3
Cairo	.....	.....	3.0	3.3

It is seen, then, that from a point not far above Memphis to Cairo the flood of 1890 was below that of 1882 by amounts increasing to about 1.8 feet at Fulton and 3 feet at Cairo, and that these quantities are generally a little greater for the flood of 1883. With a flood so much lower along this principal part of the escape front of the St. Francis, a much smaller maximum escape than those of 1882 and 1883 must be expected and must have occurred. But that of 1882 was estimated by Mr. Stewart at 611,000 cubic feet per second, and that of 1883 at 413,000 cubic feet per second, by Mr. Johnson. The observations under Captain Leach give for the water crossing the railroads west and southwest of Memphis, in 1890, quantities varying from 484,000 to 579,000 cubic feet per second, or about the same as in 1882 and 1883, although the river above was so much lower.

Observations on escape over banks and through crevasses, and on flow over railroads and through railroad trestles, are exposed to a much larger percentage of error than those on the regular discharge of a river; even the latter are subject to considerable errors. Referring to the discharges at Memphis, given in Captain Leach's report, it will be seen that on March 31, 1890, the observed discharge was 1 313,000 cubic feet per second, and that on April 1, with the gauge 0.08 foot higher, the discharge was observed as 1,205,000 cubic feet per second, the latter being 108,000, or 8 per cent. less, with very little probability of any such change in the actual river flow. Observations along a railroad may easily have several times this percentage of error.

Captain Leach estimates the maximum flow in 1890, over the latitude of Memphis, as 423,000 cubic feet more than the maximum flow over the latitude of New Madrid. It is difficult to see where this enormous increase could come from. He also etimates the maximum flow across the parallel of Helena, in 1890, at 218,000 cubic feet per second less than that across the parallel of Memphis. It is equally difficult to see what could cause this diminution.

There is a method of obtaining the maximum swamp flow across the latitude of Memphis, in 1890, other than that of measuring the flow across railroads, namely, to subtract from the maximum flow across the parallel of Helena the flow in the river proper at Memphis one day before. The measures of the flow across the Kansas City, Springfield and Memphis Railway between March 17 and 19, and again between March 28 and 29, give nearly equal values to this flow. As during this period there was little variation in the gauge readings from Memphis to New Madrid, the swamp flow appears to have been a nearly steady stream, even if the observed values of its flow were too large. On March 29, having been a stream with steady discharge at Memphis for ten days, it must have had about the same steady discharge at Helena. The date of the maximum return flow at Helena is indicated closely by the date of maximum gauge reading there on March 28. The average Memphis discharges in the river proper from March 29 to April 1 are but 45,000 cubic feet less than those from March 17 to March 20; that is, the Memphis discharge from March 17 to April 1 varied but little; hence the maximum flow across the latitude of Memphis would be but two or three days before that at Helena. On April 3 the first discharge at Helena was measured as 1,547,000 cubic feet per second. The river had then fallen 0.4 foot from its maximum gauge reading of March 28. The discharge curve of 1882 at Helena gave higher discharges for like gauge readings immediately after the maximum than before, so we may take this 1,549,000 cubic feet per second for the Helena discharge on March 28, 1890. This discharge was the result of two streams. One of them passed Memphis March 27, in the main river, and was observed as 1,263,000 cubic feet per second; the water in the other passed Memphis, in the St. Francis bottoms, as a nearly steady stream on March 25 and 26. As this stream had been nearly steady opposite Memphis since March 18, it must by March 28 have become nearly steady, with the same discharge at Helena, only 50 miles below in a direct line. Subtracting 1,263,000 from 1,547,000, the difference, 284,000 cubic feet, should be the value of the swamp flow opposite Memphis at the time of its maximum

on March 26, 1890. It differs widely from the 484,000 cubic feet per second observed as the flow across the railroad. This wide difference in results obtained by methods which are both good is only another indication of the uncertainties which are large in measurements of the main river and still greater in those of escapes or swamp flows.

In this discussion thus far I have considered chiefly the flows down the valley at Memphis and Helena in 1890, in order to avoid the large uncertainties in the escape measures of 1882. Captain Leach has rather compared the flood of 1882 with that of 1890, finding a relative change in flow between Memphis and Helena of 267,000 cubic feet. But as this value is obtained on the supposition that in 1890 the total maximum flow past Helena was 218,000 cubic feet per second less than that past Memphis; if the last figures are unreliable the first are also. Captain Leach's estimate that the maximum total flow past Memphis in 1890 was 1,835,000 cubic feet per second is for the date March 17; if the date March 31 had been used, his result would have been reduced by only 23,000 cubic feet. Hence the difference between his results and mine does not in any great degree arise from my taking March 26, instead of March 17, for the date of the maximum flow across the latitude of Memphis.

The acceptance of Captain Leach's results requires us to accept as true the following statements: (1) Although, above Fulton, the river was from 1 to 3 feet lower in 1890 than in 1882 and 1883, yet the escape into the St. Francis Bottom was about the same. (2) The maximum flow down the valley, including the flow in the St. Francis Bottom, in 1890, increased from about 1,412,000 cubic feet per second at New Madrid to 1,835,000 at Memphis, an increase of 423,000, and then diminished to 1,617,000 at Helena, a diminution of 218,000. (3) For the diminution between Memphis and Helena, the theory is advanced that levees were the cause. The increase of 423,000 cubic feet between New Madrid and Memphis is left unexplained by this theory, as the levees there both in 1890 and in 1882 were practically open.

In view of the improbability that these assumptions are true, it only remains to attribute the results obtained by Captain Leach to errors arising from the uncertainties in measurement of discharge over and through many miles of railroad, and to errors in measuring the discharge of the river proper. It seems more probable, on the whole, that the total flow across the parallel of Memphis in 1890 was about the same as that across the parallel of Helena, and that it was, as at New Madrid and Helena, about 200,000 cubic feet per second less than in 1882.

(2) Captain Leach's conditional conclusion that the maximum discharge of a given flood, when confined, will be "but little greater than the maximum discharge, in the channel, of the same flood unrestrained," depends on the opinion that the maximum flood across the latitude of Helena, in 1890, was less than that across the latitude of Memphis by 218,000 cubic feet. As the premise is not established the conclusion is not proved.

The opinion seems to underlie this conclusion, that in some unknown way a great flood can be confined and carried down the river when it is so leveed as to prevent any escape, with little increase in the maximum discharge over that of the river proper without levees. The inaccuracy of such an opinion can be shown by referring to the flood of 1882. At Columbus, from February 22 till March 3, 1882, or for ten days, the discharge varied from 1,603,000 to 1,518,000 cubic feet per second, or in round numbers exceeded 1,500,000 cubic feet per second. Now suppose that this flow had been steady for the period at 1,500,000 at Cairo, and that there had been levees so high as to contain this discharge, and to keep out all water from tributaries as far down as Hays' Landing, 553 miles from Cairo. On February 22, 1882, the Hays' Landing gauge was 1.4 feet below its maximum for that year, and the discharge was 952,000 cubic feet per second. When the Mississippi River has no escape over banks and no change in flow of tributaries, it is well known that flood waves travel down it at the rate of about 80 miles a day, this rate including any delay due to the reservoir effect of the main river. With high levees there would be no escape. Taking this rate seven days after February 22, the flood-wave from Cairo would reach Hays' Landing, and the river surface there would cease to rise The flow being supposed steady at Cairo at 1,500,000 cubic feet per second, during this time the river surface, confined by levees, in any intermediate stretch could only cease to rise when the flow in at its upper end equalled the flow out at its lower end. Of the ten days, then, at Cairo, during which there was a steady flow of 1,500,000 cubic feet per second, only seven days would be needed to give the same steady flow of 1,500,000 cubic feet per second at all points on the river as far down as Hays' Landing.

It may be objected that sufficient account has not been taken of the reservoir effect of the river proper. This can be estimated approximately. Assume that the confined flow of 1,500,000 cubic feet would gradually increase flood heights in descending the river, so as to amount to 6 feet at Hays' Landing, or that the reservoir would have an average height of 3 feet for 553 miles, and assume that the levees are on the banks of the river and on an average one mile apart. The flow being 1,500,000 cubic feet per second at Cairo, and at maximum about 1,000,000 at Hays' Landing, the res-

ervoir is being filled at the rate of about 500,000 cubic feet per second, and at this rate a single day's flow would fill it. Add this day to the seven and there results in all eight days from February 22 before the constant flow of 1,500,000 cubic feet would be established between the high levees at all points between Cairo and Hays' Landing, and this steady flow would then continue on March 2 and 3, at the same value. Now the actual maximum discharge observed at Hays' Landing in 1882 was 1,019,000 cubic feet per second, and a steady flow of 1,500,000 from Cairo to Hays' Landing would have increased the maximum discharge at Hays' Landing by nearly 50 per cent., which is not "a little greater," but is a good deal greater.

It must be noted that thus far the tributaries have been supposed to be kept out of the main river. As this is impossible, the flow at Cairo of 1,500,000 cubic feet, in 1882, would result at Hays' Landing in a maximum flow about 200,000 cubic feet greater, to which is to be added the escape above Columbus, thus giving a still higher percentage of increase.

It is believed that these considerations sufficiently establish the principle that, with levees from Cairo down so high as never to be broken, whenever for ten days the flood discharge at Cairo exceeds a given amount, the maximum discharge at points below will be larger than that amount.

It must be noted that the steady flow at Cairo for ten days does not give the maximum flow at points below, for a confined river, but only a limit below which that flow can not fall. The actual flow for a confined river would be greater than this limit, from the fact that in the ten days at Cairo the maximum discharge would be greater than the least discharge (which has been used) in that time, and from the further fact that heavy rains in the valleys of the Mississippi and of its tributaries below Cairo might add over 200,000 cubic feet per second to the Cairo discharge.

C. B. COMSTOCK,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.,
President Miss. River Commission.

NEW YORK CITY, *June* 30, 1890.

APPENDIX D.

STATEMENT OF LENGTH AND DISTRIBUTION OF FRONT LEVEE LINES IN THE ALLUVIAL VALLEY OF THE MISSISSIPPI.

MISSISSIPPI RIVER COMMISSION,
OFFICE OF THE SECRETARY,
St. Louis, Mo., August 12, 1890.

SIR: Referring to my statement of the approximate length of levees existing before the late flood, forwarded last May 3, I now submit a revised statement, obtained from later data, and showing small changes from the approximate lengths:

Length of main front levees in miles.

Right bank.	Miles.	Left bank.	Miles.
Alton to Cape Girardeau	7½	Alton to Cape Girardeau	47¾
Cape Girardeau to Cairo (Bird's Point)	7½	Cape Girardeau to Cairo (Bird's Point)	1¼
Cairo to Helena	114¾	Cairo to Memphis	12
Helena to Cypress Creek (head Tensas Basin)	52¾	Memphis to Vicksburg	284
Cypress Creek to Louisiana State line	80¼		
Louisiana State line to Red River	223	Vicksburg to Baton Rouge	48½
Red River to the Forts	274¼	Baton Rouge to the Forts	195¾
Total	752½	Total	541½

Total length of main front levees in alluvial valley, 1,294 miles.

The levee lengths from Alton to Grand Tower, and from Commercial Point to near Cairo, are derived from our surveys of 1888 and 1889; and from Grand Tower to Commercial Point, 47.3 miles, from the survey of 1884. It is not thought that any considerable addition has been made to these levees, especially since 1888.

The lengths from Cairo to Island No. 1 are from the survey of 1877; from Island No. 1 to Frame's Chute, near Memphis, excepting at Plum Point Reach, from the surveys of 1883 and 1885, and on right bank, from Frame's Chute to Commerce, from surveys of 1877 and 1878. These lengths are the same as those on the levee plots to Feb-

ruary, 1877, and it was stated at Captain Leach's office to Mr. Ockerson, whom I sent last January to compile levee information at the Memphis offices, that there were no records there of new levees on the St. Francis front, excepting at Plum Point Reach and Helena.

The lengths on the right bank from Walnut Bend to Cypress Creek, excepting near Helena, are from the surveys of 1881 and 1883, and are the same as shown on the levee plots of February, 1887.

The levee lengths of the Plum Point Reach, vicinity of Helena, Yazoo Front, Tensas Front down to Donaldsonville, and left bank, Baton Rouge to Donaldsonville, are revised to February 1, 1890. Statements of levee built since the date of our survey were derived from the district officers and from the levee engineers of the different levee districts.

Below Donaldsonville the lengths are taken from the 20,000-scale Coast Survey charts, showing topography of 1871 to 1875, and additions made thereon by the State engineer of Louisiana, bringing the data down to February 1, 1890. There is no information here of levees below the forts.

The lengths given do not include spurs nor loops not in the main front line; the Laconia Circle levee is shown as 18 miles long, but only its river front is considered as of the main front line. Neither do the lengths include railroad embankments.

Very respectfully, your obedient servant,

CHAS. F. POWELL,
Captain, Corps of Engineers.

The PRESIDENT MISSISSIPPI RIVER COMMISSION.

APPENDIX E.

REPORT OF CAPTAIN CHARLES F. POWELL, CORPS OF ENGINEERS, SECRETARY, MISSISSIPPI RIVER COMMISSION, AND ASSISTANT TO ITS CONSTRUCTION COMMITTEE; IN CHARGE OF THE ST. LOUIS OFFICE OF THE COMMISSION.

MISSISSIPPI RIVER COMMISSION,
OFFICE OF THE SECRETARY,
St. Louis, Mo., June 4, 1890.

At the beginning of the year, June 1, 1889, for which this report of operation is rendered, the available balance of the Commission appropriation was $8,886.26. No appropriation has been made during the year. Current expense, consisting principally of salaries, reduced the balance, so that the civilian members of the Commission have not been paid since November 15, 1889. These gentlemen preferred not to draw their salaries until more funds were provided, in order to permit an inspection of the river and its improvement works; it was authoritatively decided, however, that accruing obligations should be paid as far as the funds permitted; and since the statutes prohibit the incurrence of an expense in advance of an adequate appropriation therefor, except in certain special cases not here applicable, the result has been no river inspection since May, 1889, nor any Commission meeting since June of the same year. The balance of funds now available is $67.59, which will be exhausted during the month, leaving a deficiency at June 30, of $5,625 for Commissioners' salaries.

Of the Commission fleet, the survey-boats *Illinois* and *Kentucky* have continued to be temporarily loaned to the river survey, and the *Pioneer* to the general service. The house of the survey-boat *Mississippi* has also remained as at last report; its hull and that of the *Tennessee* have been condemned and disposed of; the house of the latter is now carried on an old general-service barge. The three steam-launches of the Commission are still temporarily transferred, one for use in the third district, and two in the fourth. The steamer *Patrol* was received back from the first and second districts in July, and then loaned to the river survey, where the steamer still remains.

No field operations were conducted during the year at the expense of the Commission appropriation. In the office special effort was made to obtain the notes of, and to compute the old and uncomputed discharge measurements, as well as current ones; the tabulation of results from the year's final computations are appended; this completes the discharge results to December 31, 1889, except those from measurements of 1889 at Red River Landing and Warrenton, and in Old River, and the Atchafalaya, whose final computation is now in hand, and also except the results at Carrollton, 1889, the notes of which have not been received. The appended tabulation also includes results of the 1890 discharge measurements at Wilson's Point, Skipwith Break, and New Madrid; notes of other discharge measurements of this year have not been received.

An old report, consisting of explanatory text, tabulated results and plates, upon the regimen elements of the river from Cairo to the Gulf at bank-full and medium stages, was published during the year in pamphlet form, and, with two additional tables, is here appended at the suggestion of the President of the Commission.

The report of the results of an investigation of the relation between mean bank height and mean high water at and near certain gauge stations below Cairo is also appended at General Comstock's instance.

An extended profile of levee and banks and showing certain water lines, required by a Commission resolution of 1885, was nearly completed and has been traced as far as made; I thought it desirable to bring this profile to a late date by showing upon it the later highest flood and the heights of present levees; the needed levee information has not yet all been obtained. An old plot of the levees of February, 18-7, on some sets of the inch-mile maps, made for distribution to the members of the Commission, was completed, and a plot of the levees of February, 1890, partly added thereto, and that part placed on a set of the 20,000-scale charts; all the required information as to the locations of the levees of 1890 is not yet received; the lacking part is soon expected. Copies of the completed profile and the maps showing levee lines can promptly be furnished the Commissioners after the last of the levee data is received.

An analysis of the costs of construction and maintenance of certain bank protection works, based upon the total expenditures therefor and the amount of effective work remaining, has been made, a summary of whose results, with explanations of the methods of deriving them, it is expected to lay before the Commission at an early time. Examination has also been made to find the costs of United States levees by accounting for all the expenditures from levee allotments; available data for determining the average costs per unit are rather meager, and a revision and extension of the examination are in view when more information is obtained as to the length and dimensions of certain levees.

A detailed and systematic investigation as to the relation of river-bed to river stage and as to the effect of outlets on the bed is well advanced. It is hoped to obtain results which will be deemed satisfactory because supported by observed facts. The encouragement as to outlets, and especially all-stage or nearly all-stage outlets, is not so good, since pertinent observations are very limited even after counting some old hydrographic plots of the Delta Survey and Coast Survey not heretofore used, it is believed, for these measurements. I judge it would be advantageous to have located cross-sections of the river below Red River systematically sounded at intervals throughout a year or more, making two to four sets of soundings at each section for a mean and having two to four sections at mile intervals at each locality and the localities taken where crevasses might be expected and then intermediate ones spaced all the way to the Head of the Passes.

Following the spirit of the Commission resolution that the publication of the gauge records be continued under the appropriation for the river survey, all work concerning water-gauges, river stages, etc., is reported upon in connection with the survey operations.

Mr. J. A. Ockerson, principal assistant in the office, returned to the service of the Commission last December. He has been mostly engaged, and it is expected to have him so continue, in the study of river physical data and the preparation of the levee record, as well as on some survey work. His familiarity with the field operations and care and accuracy of work make his assistance of much value. The discharge computations were generally made by Assistant Kivas Tully and Messrs. G. H. Johnson and L. M. Mann, to whom credit is due for care and patience in the work.

Respectfully submitted.

CHAS. F. POWELL,
Captain, Corps of Engineers.

The PRESIDENT OF THE COMMISSION.

APPROPRIATIONS.

For Mississippi River Commission, surveys, examinations, investigations, etc., Mississippi River and tributaries:	
Act June 28, 1879	$175,000
Sundry civil act, June 16, 1880	150,000
Sundry civil act, March 3, 1881	150,000
Sundry civil act, August 7, 1882	150,000
Sundry civil act, March 3, 1883	150,000
	775,000

For Mississippi River Commission, assistant engineers, office expenses, and contingencies:	
Sundry civil act, July 7, 1884	$75,000
Sundry civil act, October 2, 1888	35,000
Deficiency act, October 19, 1888	25,000
	135,000
For surveys, examinations, and investigations, Mississippi River and tributaries:	
River and harbor act, July 5, 1884	75,000
For continuing survey, Mississippi River:	
River and harbor act, August 5, 1886	30,000
River and harbor act, August 11, 1888	75,000
	105,000

Mississippi River improvements under the Mississippi River Commission.

For river improvements above Cairo, including certain specified harbors and localities: *	
Act, July 5, 1884	$720,000
For river improvement below Cairo:	
Act, March 3, 1881	1,000,000
Act, January 19, 1884	1,000,000
Act, August 5, 1886	1,531,250
Act, August 11, 1888	1,850,000
	5,381,250
For river improvements below Cairo, including certain specified harbors and localities:	
Act, August 2, 1882	4,123,000
Act, July 5, 1884	1,150,000
	5,273,000
For specified localities below Cairo:	
Memphis (act, July 5, 1884)	200,000
Memphis (act, August 5, 1886)	56,250
New Orleans (act, August 5, 1886)	75,000
New Orleans (act, August 11, 1888)	200,000
Red and Atchafalaya rivers (act, August 5, 1886)	187,500
Red and Atchafalaya rivers (act, August 11, 1888)	250,000
Greenville (act, August 5, 1886)	37,500
Greenville (act, August 11, 1888)	75,000
Vicksburg (act, August 5, 1886)	75,000
Vicksburg (act, August 11, 1888)	150,000
Hickman (act, August 5, 1886)	18,750
Hickman (act, August 11, 1888)	70,000
Columbus (act, August 5, 1886)	18,750
Columbus (act, August 11, 1888)	25,000
Lake Bolivar (act, August 11, 1888)	150,000
Helena (act, August 11, 1888)	75,000
	1,663,750

* Eight hundred thousand dollars were appropriated by the act of August 2, 1882, for expenditure in accordance with the plans, specifications, estimates, and recommendations of the Mississippi River Commission, but the work was not assigned to the supervision of the Commission.

Money statement.

July 1, 1889, amount available		$6,229.85
April 15, 1890, amount received by transfer of property to other appropriation	$278.16	
May 27, 1890, amount received by transfer of property to other appropriation	116.64	
		394.80
		6,624.65
June 30, 1890, amount expended during fiscal year, exclusive of outstanding liabilities, July 1, 1889	6,508.15	
Outstanding liabilities*	116.50	
		6,624.65

List of civilian engineers employed during the year to May 31, 1890, by the Mississippi River Commission under sundry civil act of October 2, 1888.

Name and place of residence.	Time employed.	Compensation per month.	Where employed.	Work on which employed.
	m. *d.*			
J. A. Ockerson, St. Louis, Mo	1 15	$200.00	St. Louis	Mississippi River Commission.
Kivas Tully, St. Louis, Mo	2 0	175.00	do	
E. H. Twining, New York, N, Y	3 0	175.00	New York	

CHAS. F. POWELL,
Captain Corps of Engineers,
Secretary Mississippi River Commission.

Approximate value of plant belonging to appropriations for Mississippi River Commission and survey of Mississippi River.

Mississippi River Commission.		Survey of Mississippi River.	
Item.	Amount.	Item.	Amount.
One steam-boat, patrol	$10,000	Three launches, Nos. 5. 6 and 7	$5,400
Three launches, Nos. 1, 3, and 4	3,000	Current meters, and outfit	300
Two quarter-boats	2,000	Outfit	500
Three quarter-boat cabins	900	Tools and appliances	25
Skiffs, etc	25	Offiee instruments	113
Outfit	2,825	Type, etc	60
Tools and appliances	575		
Surveying instrument s	12,000	Total	6,398
Drawing instruments	700		
Office furniture	700		
Printing presses, etc	675		
Current meters, and outfit	1,000		
Total	34,400		

* Does not include salaries, $5,625, of civilian members from November 16, 1889, to June 30, 1890.

Chart statement.

	Mississippi River Commission alluvial valley map.	Survey of Mississippi River.	
		Inch-mile chart, Cairo to head of passes.	Detail charts, $\frac{1}{20000}$ scale, Cape Girardeau to Donaldsonville.*
	Sets.	*Sets.*	*Sheets.*
On hand May 31, 1889	555	404	17, 217
Received	.....	.....	36, 000
Sold	28	$10\frac{11}{36}$	37
Issued free	45	$74\frac{25}{36}$	9, 980
On hand June 1, 1890	482	319	43, 200

* Seventy-one charts to the set; 54 charts now published.

COMMERCIAL STATISTICS.

Statement of freight carried between St. Louis, Missouri, and New Orleans, Louisiana, by the New Orleans Barge Line, 1868 to December 31, 1889, inclusive, furnished by Mr. H. C. Haarstick, president of the St. Louis and Mississippi Valley Transportation Company.

Year.	Transported down stream.			Transported up stream.	Total carried.
	Package freight.	Bulk grain.	Total down stream.		
	Tons.	*Bushels.*	*Tons.*	*Tons.*	*Tons.*
1868	85, 580	.....	85, 580	16, 500	102, 080
1869	92, 620	.....	92, 620	22, 300	114, 920
1870	173, 986	.....	173, 986	58, 080	232, 066
1871	136, 774	336, 960	146, 134	61, 550	207, 684
1872	202, 430	1, 847, 880	253, 760	77, 792	331, 552
1873	116, 119	1, 482, 840	157, 309	33, 226	190, 535
1874	117, 266	1, 536, 840	159, 956	19, 975	179, 931
1875	78, 264	332, 640	87, 504	18, 053	105, 557
1876	92, 255	1, 915, 920	145, 475	22, 619	168, 094
1877	85, 153	4, 429, 080	208, 183	11, 769	219, 952
1878	114, 075	5, 887, 080	277, 605	19, 258	296, 863
1879	110, 935	6, 657, 120	295, 855	19, 582	315, 437
1880	115, 400	17, 022, 960	588, 260	24, 283	612, 543
1881	125, 000	12, 933, 000	513, 527	101, 018	614, 545
1882	80, 090	8, 189, 425	328, 411	64, 949	393, 360
1883	95, 424	11, 178, 303	412, 884	41, 055	453, 939
1884	117, 528	7, 093, 424	313, 029	25, 572	338, 601
1885	97, 745	8, 811, 487	339, 677	18, 151	357, 828
1886	81, 717	9, 215, 361	334, 596	47, 651	382, 247
1887	87, 930	11, 563, 979	417, 191	78, 453	495, 644
1888	82, 277	8, 119, 881	310, 137	47, 118	357, 255
1889	96, 508	14, 999, 685	515, 211	34, 253	549, 464
Total	2, 385, 076	133, 553, 865	6, 156, 890	863, 207	7, 020, 097

In addition to the above this company report having transported southward between the years 1868 and 1877 an average quantity of 15,000 tons of ice per annum, and between the years 1878 and 1889 an average quantity of 12,000 tons of ice per annum.

Mr. Haarstick says "in this connection would like to refer to the great difference in tonnage in the column of bulk grain in the past ten years. The cause for this is short crops in this country whenever the amount transported falls below 9,000,000 bushels. The amount we now transport could in my opinion be doubled with almost the same plant that this company now owns, if we had an improved river with 10 feet of water in the channel the year round. Usually when the new crop of wheat is sent into the market we are troubled by low water, and by reason of it can only load

about 40 per cent. of the capacity in each barge, and in addition to this our boats consume at least two or three times the time in going from St. Louis to New Orleans; this necessitates the advance of rates of freight, and in consequence lower markets for the cereals in our market."

Customs statistics for the port of New Orleans for 1889.

Shipping.	Entrances.	Clearances.	Registered tonnage.
	No.	*Tons.*	*Tons.*
Coastwise	260	248	772,062
Foreign	866	845	1,833,218

Value of foreign imports (includes $415,260 received in cars)	$14,740,474
Value of foreign exports	100,609,458

Number and tonnage of merchant vessels navigating the Mississippi River below Cario, Illinois, January 1 to December 31, 1889, sea-going vessels not included.

[Compiled at office of the Mississippi River Commission, from reports furnished by the United States local inspectors of steam-vessels in the fourth, sixth, tenth, and part of seventh inspection districts, and statement of vessel-owners.]

Hailing port.	Main terminus of route.	Steam-boats, passenger and freight.	Steam-boats, towing.	Steam-boats, transfer.	Steam-boats, ferry.	Steam-boats, miscellaneous.	Barges and produce boats.	Maximum loaded draught.	Registered tonnage.	Carrying capacity.	Freight carried (approximate).	Persons employed (approximate).
		No.	*No.*	*No.*	*No.*	*No.*	*No.*	*Feet.*	*Tons.*	*Tons.*	*Tons.*	*No.*
Pittsburgh	New Orleans	.....	2	.....	.....	.....	.....	.....	1,116.01	1,495.45	.....	50
Pittsburgh*	Memphis and New Orleans	.....	15	.....	.....	.....	1,000	8	*	450,000.00	1,000,000	525
Wheeling	Various	.....	6	.....	.....	.....	82	8½	1,026.75	1,026.75	45,050	208
Cincinnati	New Orleans and Memphis	13	.....	.....	.....	.....	.....	9½	13,416.75	16,818.00	230,926	1,115
Cincinnati	New Orleans and Louisiana Bend	.....	6	.....	.....	.....	51	.....	*	26,000.00	157,000	
Louisville	New Orleans	8	.....	.....	.....	.....	.....	.....	2,499.25	3,099.07	.....	200
Cairo	Columbus, Ky	.....	.....	1	.....	.....	.....	3½	312.04	312.04	.....	10
St. Louis	New Orleans	16	12	.....	.....	.....	.....	8	22,196.80	29,743.71	400,000	1,800
St. Louis	New Orleans	.....	.....	.....	.....	.....	80	9 8/12	*	128,640.00	700,000	
Memphis	Various	34	11	4	11	7	.....	.....	11,286.73	18,072.67	846,700	2,010
New Orleans	Various	107	13	5	13	.....	28	.....	*	†67,500.00	†545,000	4,440
Total		178	65	10	24	7	1,241	.....	51,854.33	742,707.69	‡3,924,676	10,358

* Not known.

† Estimated.

‡ The transportation of this quantity of freight by rail within the same period would require the departure from a given point of a train of 20 cars, 15 tons each, about every 40 minutes.

Total number of steam-boats, all classes, barges, and produce boats, 1,525.

The president of the St. Louis and New Orleans Anchor Line states that the extreme low water of the fall and part of the summer, 1889, prevented its packets from loading to more than about one-half their capacity north of Cairo, and that for quite a time the packets could not load to near their carrying capacity north of Memphis; as the company's down traffic originates at the north of Cairo the amount was consequently diminished by an unusual low water.

REGIMEN ELEMENTS OF THE MISSISSIPPI RIVER, BANK FULL AND MEDIUM STAGES, CAIRO TO THE GULF OF MEXICO.

[From surveys by the Mississippi River Commission, the Corps of Engineers, U. S. A., and the U. S. Coast and Geodetic Survey, 1871–1884. Compiled under the direction of Prof. Henry Mitchell, member Mississippi River Commission, and of the secretary of the Commission, by L. C. Jones, assistant engineer, 1887, with additional tables compiled at the secretary's office, 1890.]

REPORT OF ASSISTANT ENGINEER L. C. JONES ON THE HISTORY OF THE WORK, ETC.

Work upon the high-water regimen of the Mississippi River was begun in April, 1881, and the first portion (since revised), from Cairo to Memphis, which was blueprinted the following September, was based upon a compilation of cross-section elements by Mr. Robert E. McMath, as far as Ashport, Tenn., and the remaining data to Memphis compiled by myself from the surveys of Col. J. A. Monroe, and the surveys of Plum Point Reach by Mr. W. H. Powless. (See supplemental report.) The work was then discontinued till the end of the field season of 1881–'82, and not resumed till about May, 1882. It was interrupted each fall and not resumed till the following spring, and was also subject to the interruptions consequent to the determination of elements of cross-sections, bank-full and medium stage, for each two miles of river.

The work was completed and plotted to Donaldsonville, La., on July 28, 1885, where the surveys of the Mississippi River Commission met those of the U. S. Coast and Geodetic Survey. On August 31, 1885, I left St. Louis for Washington, D. C., according to instructions from Capt. Thomas Tuttle, secretary Mississippi River Commission, arriving there September 2, and began that day tracing the hydrographic sheets in the Coast Survey Office, interpolating soundings from the original note-books where there was not a sufficient number of them plotted to give a good cross-section. These charts, from Donaldsonville to within a couple of miles of the Head of the Passes, were on a scale of 1:20,000, and were ten in number. The short reach above the passes comprised two charts, one on a scale of 1:4,800, and the other 1:10,000. There were five charts covering the passes, viz: Southwest Pass, two, scale 1:4,800; South Pass, two, scale 1:4,800; Pass à l'Outre, one, scale 1:20,000. This latter pass is considered as the main river on the plot, and the elements of cross-section, etc., considered only as far as the head of East Pass.

These tracings completed, I returned to St. Louis, arriving on Friday evening, September 25, 1885, and the next day commenced the measurements necessary. The cross-sections had first to be increased to a width equal to a scale of 1:10,000, and then the profiles plotted, etc., the work being completed January 26, 1886.

DESCRIPTION OF PLOT.

The High Water Regimen of the Mississippi River is intended to show the relations which the elements of cross-sections bear to each other.

To illustrate these the river has been divided into sections of various lengths, attention being paid to islands and their accompanying chutes, it being always the plan to make a section begin at the head and end at the foot of a chute, where one of any appreciable magnitude exists. In all other instances it has been the rule to divide the river into bends and half-bends, at the point of crossing, or reversion of curvature. The plot shows the mean area, mean width, mean depth, mean thalweg depth, by which is meant a channel having a width of five hundred feet, mean maximum depth; curvature in ratio of arc and chord, and in degrees per mile; slope per mile; and oscillation for each section of the river. The mean of each element of each section is plotted on the same ordinate, which is that drawn through a point equal to the distance, in feet, of the middle of the section below Cairo. All values relate to a bank-full stage. Each value plotted is the arithmetical mean of all observations of each element of cross-section in the section of the same number in the sketch of the river.

The following table gives the distances between cross-sections, etc.:

Locality.	Distance.	Surveyed by.	Date.
Between Cairo and Ashport	One-half mile	Col. J. A. Monroe	1879
Between Ashport and Fulton	One-fifth mile	Mr. W. H. Powless	1880
Between Fulton and Memphis	One-half mile	Col. J. A. Monroe	1879–'80
Between Memphis and Commerce	One-fourth mile	Gen. C. B. Comstock	1877–'79
Between Commerce and Austin	do	Mr. J. A. Ockerson	1880
Between Austin and Delta	do	do	1878
Between Delta and Arkansas City	do	do	1881–82
Between Arkansas City and Greenville	One-fifth mile	do	1881
Between Greenville and Lake Providence	One-third mile	Mr. G. Y. Wisner	1881–'82
Between Lake Providence and Paw-Paw Island.	One-fourth mile	Mr. C. M. Winchell	1882
Between Paw Paw Island and Big Bayou	do	Mr. J. A. Ockerson	1881
Between Big Bayou and Natchez	do	Mr. L. L. Wheeler	1882–'83
Between Natchez and Bayou Sara	do	Mr. J. A. Ockerson	1882–'83
Between Bayou Sara and Donaldsville	do	Mr. C. M. Winchell	1883
Between Donaldsville and Gulf of Mexico.	do	U. S. Coast and Geodetic Survey.	1871–'79

Horizontal distances were measured on a line midway between banks and plotted to a scale of 50,000 feet = 1 inch. Full lines in elements of cross-sections show values for main channel alone. Broken lines, and broken and dotted lines, in area, width, and mean depth, show respectively the main channel and principal side channel combined, and all channels combined.

Mean maximum depth is represented by a dotted line. The curvature in ratio is expressed by a full line terminating in the symbol $\wedge$, and the curvature in degrees per mile, which has the same origin as the former, is expressed, when exceeding the ratio, by a broken line beyond the ratio symbol, and ending in the symbol $\times$, and when less than the ratio, simply by the symbol $\times$ crossing the full line.

Slope per mile is expressed by simple full lines, and where it conflicts with the oscillation the origin of the slope ordinate is denoted by a short line drawn at right angles to it.

Oscillation is denoted by full lines, which are cut at the upper end by a sloping line drawn between the gauge points, that are used to determine the oscillation.

When the oscillation ordinates extend beyond the slope ordinates, the origin of the slope ordinate is marked by a short line at right angles to itself, and terminated by a small circle, and the oscillation ordinate continued in a broken line to its contact with the sloping line drawn between the gauges.

The sketch of the river on the plot is not drawn to scale but traced from the Levee Map, by Messrs. Molitor & Craig, and has been broken and shortened in several places, in order to make the numbered sections correspond as nearly as practicable with the ordinates of mean elements.

The sketch was broken at sections Nos. 138 and 167, and swung to the right. The index sheets drawn in the sketch refer to the inch-to-the-mile charts by Mr. Molitor. At section No. 135, the line representing the mean width was broken and raised, in order to prevent confusion with the thalweg line, which it would have crossed at several points if left undisturbed.

The base of the areas is taken at 180,000 square feet, and plotted to a scale of 60,000 square feet = 1 inch.

The base of widths is taken at 4,000 feet, and plotted to a scale of 1,200 feet = 1 inch.

Mean depth, mean thalweg depth, and mean maximum depth, are all plotted from the same base = 0, and are plotted to a scale of 30 feet = 1 inch.

Curvature in ratio and degrees per mile are referred to the same base = 0. In the scale of the former, .3 = 1 inch, and in the scale of the latter, 6° = 1 inch.

Slope per mile is plotted to a scale of .3 feet = 1 inch, and begins at (0) zero.

Oscillation is referred to that at Memphis = 36.1 feet, and is plotted to a scale of 6 feet = 1 inch. At Baton Rouge and Carrollton the plane of reference is lowered to 11 feet and 0 feet, respectively.

METHODS OF OBTAINING RESULTS.

The cross-sections used were those plotted on the office charts, scale 1:10,000, of which tracings on linen were made, and the soundings thereon reduced to a bank-full stage. All cross-sections were plotted to a horizontal scale of 1:10,000, and a vertical scale of 30 feet = 1 inch. Each cross-section was then carefully measured and checked with a planimeter, which gave the area.

The width, thalweg depth, and maximum depth of each cross-section were scaled off, and the mean depth obtained by dividing the area by the width.

The results of the measurements of these elements were tabulated in regular order, showing the value of each element in each cross-section. To obtain the values plotted, all the cross-sections within the limits of each section of river were grouped together, their individual elements summed, and a mean taken, which gave mean area, mean width, etc., for each section of river. This applies only to elements of cross-section, *i. e.*, area, width, mean depth, thalweg depth and maximum depth.

Mean slope was determined from the table of slopes, high water 1882, Mississippi River Commission records. (Report Mississippi River Commission, 1885, pages 2907–2912, inclusive.) The slopes per mile between points within the limits of a section of river were taken, and total slope for the section computed. This result being divided by the total number of miles in the section, gave the slope per mile for that section.

Curvature in ratio was obtained by measuring the distance in thousand feet chords along the mid-bank line between the extremities of each section, and dividing the distance thus obtained by the length of chord or straight line joining these extremities.

Curvature in degrees per mile was obtained by drawing circular curves, compounding or reversing them as necessary, carrying the line of curvature as nearly as possible along the mid-axis of the stream, without producing confusion by too many combinations of curves. The number of degrees of departure in a section were summed, and the result divided by the number of miles in the section, measured in thousand feet chords, along the line of curvature. The quotient thus obtained was the curvature in degrees per mile for that section.

The curves and distances were plotted and measured on a set of the small office charts, scale 1:63,360.

Oscillation was determined by taking the differences between the highest and lowest known readings on the reliable gauges. They are to be found in the Chief Engineer's Report, 1881, Part II, p. 1439, the high water readings of 1882–'83–'84, which at some of the guages are the highest known, from the Mississippi River Commission records. (Mississippi River Commission Report, 1885, pages 2909–2915, inclusive.) In plotting the elements of the passes, Pass á Loutre was considered the main branch, and the other two were treated in regard to area, width, and mean depth, as though they were chutes. The maximum depth, thalweg, and curvature, both in ratio and degrees per mile, of all three passes, are plotted separately, Pass á Loutre, however, being considered only as far as the head of East Pass, and the ordinate for the mean distance for the section plotted as the distance measured to that point. The right line represents Pass á Loutre, and Southwest Pass and South Pass are respectively represented by a broken line, and a broken and dotted line. Slope was carried only to Carrollton, there being no levels below that point.

Respectfully,

L. C. JONES,
Assistant.

SUPPLEMENTAL REPORT OF ASSISTANT ENGINEER L. C. JONES.

On August 9, 1886, I received orders from Capt. Thomas Turtle, secretary Mississippi River Commission, to revise the work of the High Water Regimen of the Mississippi River between Cairo and Memphis, and Commerce Cut-off, St. Louis Landing, Ark.

The methods employed in the determination of values are the same as used in the original work, but the data used were the surveys of Assistants J. A. Ockerson, L. L. Wheeler, and C. M. Winchell, which were made in 1883–'84–'85. In these surveys the cross-sections were taken at an average of every one-fourth mile, and frequently as many as five were taken in that distance.

The work has been replotted, and the origin of distance is the United States gauge at Cairo, and the mean of each element in each section is plotted on the same ordinate, which is that drawn through a point equal to the distance in miles of the middle of the section below the gauge at Cairo.

L. C. JONES,
Assistant.

MAY 31, 1887.

Gauge-readings relating to the means in the following tables.

Gauges.	Distance between gauges.	Elevation of gauge zeros above Cairo datum.	Slope per mile between gauges.	Gauge readings.				Extreme oscillation, 1872–1890.
				High water of 1882.	Low water of 1882.	Medium stage.*	Bank-full stage.	
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Cairo	0.0	290.84	.....	51.87	7.30	29.58	39.29	53.17
Columbus	21.3	229.14	0.27	102.77	67.26	85.02	94.00	.....
New Madrid	47.8	276.04	0.33	41.33	3.70	22.51	33.09	.....
Cottonwood Point	53.7	250.62	0.51	37.50	3.60	20.55	36.00	.....
Memphis	107.2	203.97	0.45	35.15	3.50	19.33	31.1	36.25
Mhoon's Landing	45.9	181.48	0.44	39.80	5.90	22.85	34.7	.....
Helena	30.6	161.98	0.47	47.20	8.60	27.90	43.6	48.30
White River	86.7	128.73	0.37	48.40	9.70	29.05	44.4	48.40
Arkansas City	45.1	116.47	0.32	47.07	7.50	27.28	41.8	.....
Lake Providence	104.0	89.62	0.31	38.32	5.90	22.11	36.5	42.25
Vicksburg	57.0	66.04	0.31	48.75	7.60	28.17	44.1	52.91
St. Joseph	51.0	52.74	0.30	44.90	7.80	26.35	40.4	.....
Natchez	51.8	36.89	0.26	47.75	9.70	28.72	36.3	47.75
Red River Landing	65.0	23.85	0.20	48.50	9.10	28.80	36.3	48.50
Port Hickey	44.7	13.68	0.14	47.90	17.00	32.45	44.4	.....
Baton Rouge	23.3	20.06	0.21	35.95	6.18	21.06	33.0	35.05
Plaquemine	20.2	21.06	0.13	31.30	3.80	17.55	28.0	.....
College Point	49.5	21.24	0.092	23.13	2.48	12.80	20.4	.....
Carrollton	54.0	20.91	0.096	14.95	1.00	7.95	8.9	17.30
Gulf Level	102.5	.....	0.097	.....	.....	.....	.....	.....

*Mean of high and low water of 1882.

Revised table of regimen of the Mississippi River, at bank-full stage, from Cairo to the Gulf of Mexico.

Number of section.	Distance from Cairo.	Length of section.	Mean area.	Mean width.	Mean depth.	Mean thalweg depth.	Mean maximum depth.	Slope per mile, high water, 1882.	Ratio of curvature.	Curvature in degrees.		
										Total.	Per mile.	Distance on arc.
	Miles.	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		° ′	° ′	*Feet.*
1	7.7	47,000	197,191	4,412	44.9	69.8	73.5	0.476	1:1.06	124 15	13 46	47,700
2	15.3	33,500	194,000	5,236	39.5	70.2	77.5	0.558	1:1.47	158 25	24 07	34,700
Chute, Islands 1 and 2			9,760	488	35.6							
Do			10,500	840	32.7							
3	20.4	20,200	191,775	3,273	61.6	84.5	92.0	0.550	1:1.22	146 50	37 39	20,600
4	25.4	33,450	191,962	5,079	39.4	57.5	64.9	0.449	1:1.05	185 15	28 46	34,000
Chute, Island 5			46,944	1,786	34.8							
5	30.9	24,500	216,833	5,460	40.1	64.5	71.9	0.347	1:1.11	105 10	22 03	25,200
6	35.7	25,700	196,345	4,466	45.2	63.2	93.7	0.289	1:1.15	107 45	21 05	27,000
Chute, Island 6			7,125	450								
7	40.4	24,400	218,875	4,860	45.4	63.4	68.1	0.279	1:1.05	72 20	14 51	25,700
8	46.4	39,000	173,962	4,014	44.1	69.9	77.2	0.393	1:1.43	165 55	21 34	40,600
Chute, Island 8			56,781	2,134	37.5							
9	53.6	36,800	209,672	4,873	43.4	63.5	68.9	0.188	1:1.02	87 30	12 31	36,900
10	60.3	33,300	236,048	7,544	31.8	58.8	64.2	0.228	1:1.24	183 10	28 48	33,600
11	65.3	20,400	196,475	5,716	34.7	64.7	72.7	0.228	1:1.01	46 20	11 42	20,900
12	70.2	30,600	211,565	5,874	36.4	61.1	67.1	0.574	1:1.60	211 35	34 55	32,000
13	76.6	36,800	260,010	6,971	37.4	54.2	58.5	0.450	1:1.03	223 10	30 12	39,000
14	84.4	46,300	216,401	5,310	40.9	67.0	73.5	0.593	1:1.45	199 35	21 46	48,400
15	92.2	36,020	214,080	6,372	34.8	69.7	76.9	0.532	1:1.65	194 55	27 18	37,700
16	99.2	38,380	208,630	5,040	41.9	63.5	70.3	0.520	1:1.57	177 00	22 48	41,000
17	106.4	36,600	186,964	4,928	39.3	71.7	78.5	0.629	1:1.90	195 30	26 49	38,500
18	111.4	16,900	203,708	4,887	41.9	55.3	58.6	0.494	1:1.00	38 00	12 08	16,500
19	116.2	34,000	204,822	4,880	42.6	57.3	66.1	0.464	1:1.13	152 20	22 55	35,100
Chute, Islands 16 and 17			10,833	666								
Chute, Island 18			80,203	2,647	37.9							
Second Chute, Island 18			14,904	828	35.6							
20	121.3	19,300	158,258	3,644	42.9	59.4	66.0	0.426	1:1.03	39 00	10 39	19,300
Chute, Islands 20 and 21			33,759	1,504	36.2							
21	127.6	47,500	194,630	4,813	41.2	58.5	62.8	0.213	1:1.23	132 00	14 10	49,200
22	135.7	37,800	188,529	4,746	40.9	68.1	72.8	0.566	1:2.33	211 15	28 40	38,900
23	141.3	21,500	167,989	4,501	37.8	69.7	78.1	0.534	1:1.33	136 10	30 04	23,900
Chute, Island 25			3,911	406								
Chute, Islands 26 and 27			28,038	937	33.3							
24	145.1	18,100	170,640	3,935	43.5	63.4	69.1	0.527	1:1.10	104 00	29 33	18,600
25	149.8	32,400	159,868	4,711	34.3	61.0	67.3	0.535	1:1.22	193 30	29 52	34,200
26	155.5	27,280	188,604	5,034	39.1	56.3	60.7	0.529	1:1.09	146 00	27 14	28,300
Chute, Ashport Bar			19,062	1,270	33.0							
27	160.8	28,900	236,521	7,447	32.2	52.6	56.6	0.378	1:1.15	130 30	24 05	28,600
28	165.6	21,850	200,300	5,427	38.4	51.2	54.6	0.539	1:1.15	93 15	22 22	22,000

Revised table of regimen of the Mississippi River, at bank-full stage, from Cairo to the Gulf of Mexico—Continued.

Number of section.	Distance from Cairo.	Length of section.	Mean area.	Mean width.	Mean depth.	Mean thalweg depth.	Mean maximum depth.	Slope per mile, high water, 1882.	Ratio of curvature.	Curvature in degrees.				
										Total.		Per mile.		Distance on arc.
	Miles.	*Feet.*	*Sq. Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		°	′	°	′	*Feet.*
Chute, Osceola Bar			37,325	1,331	35.2									
29	172.0	45,000	207,191	4,800	48.2	62.8	76.5	0.343	1:2.12	224	00	25	27	46,500
30	178.5	24,250	220,236	5,178	42.6	53.1	57.6	0.454	1:1.02	49	00	10	36	24,400
Chute, Island 34			34,125	1,434	38.5									
31	183.4	27,200	189,533	3,590	57.1	84.3	94.7	0.804	1:1.62	170	30	31	41	28,400
32	191.0	53,330	160,911	4,362	37.5	59.5	68.0	0.472	1:1.98	177	30	16	37	56,400
Chute, Island 35			87,493	3,244	32.7									
33	199.8	39,900	193,493	4,584	42.6	67.1	74.9	0.326	1:1.50	180	30	23	17	40,900
34	207.5	40,800	154,430	3,463	48.5	71.5	80.3	0.522	1:1.24	216	00	27	25	41,600
Chute, Brandywine Island			68,450	3,719	31.0									
35	216.2	50,900	187,348	6,003	32.5	58.7	65.8	0.433	1:1.67	279	00	27	19	54,000
Chute, Beef Island			42,482	1,343	31.3									
36	222.9	20,700	196,365	5,154	38.5	64.8	72.6	0.447	1:1.16	112	00	27	31	21,500
37	227.0	21,920	174,687	4,502	38.8	68.1	79.2	0.447	1:1.42	218	00	48	27	23,800
Chute, Old Hen Island			12,375	1,370	31.9									
38	231.0	20,800	132,094	2,995	44.1	86.0	89.0	0.322	1:1.17	121	45	31	23	20,500
39	236.4	36,300	129,375	4,868	26.6	46.1	49.1	0.451	1:1.32	179	45	25	38	37,009
Chute, President's Island			78,453	2,205	29.4									
40	242.9	31,600	191,433	5,269	36.3	52.0	53.4	0.284	1:1.13	82	00	13	58	31,000
41	249.8	41,800	158,490	4,458	35.6	57.1	60.3	0.620	1:1.63	199	00	24	32	42,800
42	256.6	30,040	169,344	4,894	34.6	49.6	50.9	0.477	1:1.14	101	00	17	33	30,400
43	263.0	37,060	134,266	4,728	28.4	41.7	43.8	0.358	1:1.05	88	45	11	00	37,800
44	269.7	34,300	185,107	6,867	27.0	56.2	59.0	0.239	1:1.18	205	00	30	20	35,700
45	276.0	32,100	194,551	6,637	31.4	65.3	79.6	0.347	1:1.76	267	50	40	53	34,600
46	281.0	20,000	175,925	4,476	39.1	57.2	70.3	0.388	1:1.18	229	30	58	33	20,700
Walnut Bend			68,703	2,350	35.8									
47	287.0	44,700	189,819	5,075	38.5	65.1	74.5	0.404	1:1.71	343	15	34	42	52,200
48	295.6	45,200	227,392	5,885	40.5	67.6	73.4	0.369	1:1.82	222	20	24	04	48,800
49	302.2	25,000	251,304	6,923	39.4	74.3	81.4	0.383	1:1.14	144	25	28	02	27,200
50	307.3	28,200	215,371	5,042	43.2	69.7	77.2	0.570	1:1.01	46	50	8	50	28,000
51	312.2	24,100	227,168	5,735	41.2	74.7	90.1	0.566	1:1.22	110	40	24	26	23,900
52	317.3	29,920	202,804	4,428	46.2	73.3	80.6	0.436	1:1.01	82	00	14	32	29,800
53	324.3	43,280	165,974	3,604	46.4	77.8	89.7	0.463	1:1.73	212	05	25	13	44,400
54	330.8	25,900	179,708	5,039	37.6	67.0	77.1	0.447	1:1.52	178	10	36	53	25,500
Chute, Island 62			11,293	407	34.2									
Chute, Island 63			51,856	1,665	34.5									
55	334.5	13,200	198,011	4,814	42.0	65.4	72.9	0.447	1:1.10	43	50	16	32	14,000
56	338.0	23,400	171,342	3,692	47.5	76.0	82.5	0.447	1:1.11	96	30	23	57	21,300
57	344.3	43,100	180,598	4,929	37.1	75.2	85.5	0.419	1:2.61	239	35	31	09	40,600
58	352.3	41,000	148,296	3,770	39.3	69.9	75.1	0.282	1:2.55	224	26	28	19	41,800

Chute, Island 66			25,229	1,170	35.1											18,400
59	357.9	18,100	181,911	3,916	46.4	64.2	68.7	0.358	1:1.00	44	50	12	53			24,000
60	361.8	24,000	155,986	4,129	37.8	66.6	70.7	0.233	1:1.73	190	20	41	50			
Chute, Island 68			60,425	1,992	35.4											17,600
61	365.8	17,500	170,109	3,420	49.7	70.2	72.6	0.262	1:1.01	54	50	16	28			29,500
62	370.2	28,900	164,489	3,755	43.8	76.5	82.3	0.358	1:1.35	179	10	32	03			
Chute, Island 69			20,667	707	41.5											13,700
63	374.2	13,500	162,771	3,375	48.2	95.8	103.8	0.143	1:1.05	61	30	23	45			39,600
64	379.1	38,700	183,942	4,301	42.8	77.1	82.5	0.242	1:1.93	198	50	26	31			27,900
65	385.4	27,300	171,625	4,068	42.2	74.1	78.6	0.311	1:2.01	216	20	40	58			
Scrub Grass Chute			21,125	997	38.1											25,700
66	390.3	24,900	183,488	4,022	45.6	73.7	79.6	0.311	1:1.09	92	00	19	53			19,500
67	394.5	18,800	171,979	3,519	48.9	89.6	94.8	0.455	1:1.04	75	00	20	19			21,900
68	398.3	21,300	198,019	4,204	47.1	74.2	78.4	0.360	1:1.13	106	00	25	32			28,400
69	402.9	28,200	180,125	3,862	46.6	80.1	86.2	0.160	1:1.08	127	10	23	38			23,000
70	407.8	22,800	196,375	3,967	49.5	100.1	110.1	0.307	1:1.85	197	30	45	18			19,400
71	411.7	18,700	183,694	3,887	47.3	71.5	75.8	0.307	1:1.00	66	10	18	02			17,500
72	415.0	15,700	163,250	4,780	34.2	73.9	80.2	0.350	1:1.24	130	30	39	25			
Chute, Island 75			53,575	1,530	34.4											17,700
73	418.2	18,800	183,437	4,053	45.2	72.9	77.1	0.297	1:1.11	46	40	13	56			14,300
74	421.3	14,000	193,708	5,173	37.5	78.7	81.6	0.297	1:1.01	66	30	24	32			
Chute, Catfish Towhead			27,690	1,130	35.1											44,400
75	427.0	46,300	191,875	4,129	46.5	90.4	98.6	0.244	1:2.05	210	20	25	01			31,400
76	434.3	30,800	224,600	5,375	45.8	73.2	76.3	0.405	1:1.77	167	10	28	06			28,400
77	439.9	28,200	197,863	3,440	58.1	95.2	99.9	0.575	1:1.25	126	30	23	31			25,300
78	444.8	23,600	205,096	5,623	36.5	72.0	77.0	0.141	1:1.16	131	15	27	24			39,800
79	450.8	39,300	185,298	3,612	51.3	88.5	92.1	0.442	1:3.67	244	30	32	26			48,000
80	459.0	47,000	184,799	4,118	44.9	81.3	85.5	0.189	1:2.40	226	00	24	52			
Chute, Island 82			9,190	920	38.5											42,400
81	467.6	44,400	187,703	3,859	48.6	86.0	89.7	0.330	1:2.64	220	30	27	28			48,600
82	476.3	47,200	188,535	4,312	43.7	73.4	75.5	0.361	1:3.52	232	15	25	15			20,800
83	482.7	20,800	221,786	5,181	42.8	62.8	64.9	0.317	1:1.00	25	40	6	31			28,300
84	487.5	29,000	217,042	5,354	40.5	65.6	69.3	0.347	1:1.27	121	00	22	33			22,590
85	492.3	22,200	198,844	4,616	43.1	73.5	76.2	0.243	1:1.07	92	00	21	36			15,000
86	495.8	14,600	190,781	3,915	48.7	95.1	97.7	0.222	1:1.01	81	30	28	42			19,700
87	499.0	19,800	176,750	4,223	41.9	78.4	82.9	0.348	1:1.17	93	20	25	01			22,709
88	503.1	23,400	187,438	4,240	44.2	65.4	68.2	0.481	1:1.08	36	00	8	22			
Chute, formerly Bullitt's Towhead			14,040	570	41.9											22,000
89	507.6	23,600	180,417	5,465	33.0	77.1	84.0	0.475	1:1.63	153	00	36	41			16,400
90	511.4	16,500	190,313	4,303	44.2	71.6	77.9	0.385	1:1.01	50	00	16	05			18,000
91	514.7	18,900	181,300	4,612	39.3	66.2	68.7	0.385	1:1.04	65	05	19	05			
Chute			10,050	584	36.8											18,800
92	518.3	18,500	183,107	3,644	50.3	79.3	85.5	0.355	1:1.05	112	30	31	36			22,200
93	522.1	21,500	182,417	3,442	52.4	97.5	103.0	0.323	1:1.67	183	00	43	28			42,000
94	528.2	43,600	200,083	4,773	41.9	64.4	71.3	0.320	1:1.14	99	00	12	27			13,000
95	533.6	13,200	199,344	4,625	43.1	67.7	73.0	0.320	1:1.01	47	30	19	19			
Chute, Island 93			21,667	1,080	38.7											32,900
96	538.0	33,200	226,703	5,949	38.1	68.1	79.3	0.320	1:1.03	104	40	16	48			41,800
97	545.6	47,000	202,286	5,224	38.7	79.0	85.9	0.304	1:1.58	140	40	17	46			13,100
98	551.2	12,700	117,417	2,847	41.3	74.1	76.3	0.302	1:1.09	120	30	48	35			
Chute, Island 95			80,210	2,640	36.0											

Revised table of regimen of the Mississippi River, at bank-full stage, from Cairo to the Gulf of Mexico—Continued.

Number of section.	Distance from Cairo.	Length of section.	Mean area.	Mean width.	Mean depth.	Mean thalweg depth.	Mean maximum depth.	Slope per mile, high water, 1882.	Ratio of curvature.	Curvature in degrees.			
										Total.		Per mile.		Distance on arc.
	Miles.	*Feet.*	*Sq. Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		°	′	°	′	*Feet.*
99	553.8	14,200	174,021	3,930	44.3	83.9	89.6	0.234	1:1.03	45	10	16	55	14,100
100	558.8	38,900	156,883	4,231	37.1	80.4	85.5	0.214	1:1.49	198	55	26	27	39,700
Chute, Island 97			43,110	1,420	35.4									
101	564.5	20,580	180,850	4,337	41.8	66.1	68.6	0.214	1:1.07	42	00	11	16	19,700
102	569.4	31,680	196,100	5,631	35.9	75.8	79.3	0.214	1:1.92	170	30	31	17	28,800
103	574.4	20,620	174,769	4,113	44.2	97.6	101.3	0.214	1:1.09	80	00	20	31	20,600
104	577.5	12,440	141,125	2,900	48.9	79.5	84.2	0.214	1:1.06	86	00	36	36	12,400
Chute, Island 102			70,688	2,108	42.3									
105	581.7	32,480	188,350	4,065	47.2	73.7	75.8	0.214	1:1.08	71	00	11	34	32,400
106	587.3	26,400	153,142	3,001	53.5	77.1	79.3	0.214	1:1.21	154	55	31	56	25,600
Chute, Island 103			55,568	2,182	40.3									
107	593.4	38,160	194,071	3,625	54.1	87.2	91.2	0.214	1:1.22	137	50	19	53	36,600
108	599.4	25,206	210,233	3,847	55.3	104.6	109.7	0.311	1:1.21	195	00	40	22	25,500
109	603.8	21,120	244,653	5,979	41.2	78.6	80.9	0.403	1:1.17	122	40	30	26	21,300
110	608.2	25,520	180,903	4,174	43.6	74.6	76.5	0.406	1:1.19	131	00	27	41	25,000
111	613.7	31,780	189,022	4,970	39.7	72.4	75.6	0.277	1:2.13	172	00	37	43	24,100
112	619.0	24,080	194,393	5,146	38.6	78.3	80.4	0.307	1:1.27	124	40	28	59	22,700
113	623.1	19,840	212,044	5,218	41.9	81.8	84.9	0.391	1:1.51	161	45	43	57	19,400
114	626.9	19,840	180,277	3,884	46.8	90.6	94.7	0.436	1:1.57	192	30	49	37	20,500
115	631.3	26,780	171,581	3,921	44.5	78.3	89.4	0.476	1:1.62	195	15	36	42	28,100
116	635.5	17,660	165,000	4,376	40.4	84.5	91.3	0.549	1:1.68	173	30	52	35	17,400
117	639.2	21,620	184,198	4,025	45.9	80.9	89.8	0.561	1:1.06	93	00	21	44	22,600
118	643.6	24,980	224,696	5,083	45.2	69.2	75.9	0.117	1:1.04	34	45	7	31	24,400
119	648.0	21,120	196,090	3,833	51.6	83.4	89.2	0.128	1:1.09	76	50	19	07	21,200
120	652.5	26,400	193,045	3,644	52.5	103.2	110.1	0.400	1:1.68	200	40	38	13	27,700
121	658.5	36,960	251,632	6,106	42.7	73.2	79.8	0.164	1:1.12	127	20	17	38	38,100
122	665.0	31,680	172,494	3,819	47.3	84.5	92.5	0.264	1:1.71	175	10	28	23	32,600
Chute, Island 113			51,875	1,627	41.2									
123	671.5	36,960	194,523	3,357	60.2	94.1	103.8	0.194	1:5.60	223	00	31	14	37,700
124	679.0	42,060	237,505	4,973	48.2	89.4	97.3	0.206	1:1.31	121	15	14	55	43,000
125	686.5	37,140	209,492	4,039	52.7	86.9	96.5	0.195	1:1.37	157	50	22	26	37,800
126	693.5	36,960	198,955	4,032	50.1	94.8	105.7	0.267	1:2.87	255	05	35	00	38,500
127	698.5	15,840	211,391	3,789	56.0	115.6	135.2	0.389	1:1.23	160	30	50	10	16,000
128	702.2	23,400	183,397	2,820	65.8	82.7	88.0	0.094	1:1.03	43	00	9	53	23,000
129	707.3	29,400	233,167	4,781	50.3	70.3	73.9	0.223	1:1.05	81	40	14	40	29,400
130	712.5	26,400	224,114	5,182	45.3	75.1	80.4	0.188	1:1.16	113	00	23	13	25,700
131	717.5	26,400	193,866	3,308	62.4	103.3	110.1	0.188	1:1.63	195	35	39	40	26,000
132	723.4	36,060	237,022	6,500	36.6	76.6	85.0	0.151	1:1.70	242	30	35	33	36,000
133	731.9	53,700	197,966	3,541	57.0	93.9	102.9	0.145	1:1.74	226	45	21	58	54,500
134	739.2	23,540	194,172	3,689	54.0	96.0	110.2	0.205	1:1.44	170	50	36	59	24,400
135	743.8	24,980	209,542	3,951	53.4	95.8	106.0	0.213	1:1.16	106	10	22	30	24,900

136	750.1	41,240	202,534	3,464	59.2	97.9	109.4	0.166	1:1.11	178 15	21 24	41,500
137	755.4	12,840	232,306	3,097	75.6	133.9	149.8	0.277	1:1.41	146 40	69 37	13,000
138	759.6	33,960	226,023	3,999	57.3	86.9	99.1	0.276	1:1.01	51 40	8 04	33,800
139	767.0	43,740	217,559	3,659	60.5	85.6	98.4	0.326	1:1.41	156 20	18 35	44,400
140	773.6	25,620	192,942	3,127	63.3	102.5	116.5	0.245	1:1.14	95 15	19 43	25,500
141	778.4	25,400	215,661	4,028	56.0	78.9	85.6	0.248	1:1.01	43 55	9 12	25,200
142	782.1	14,040	211,473	3,164	67.5	113.9	120.9	0.209	1:1.23	114 30	44 13	13,700
143	787.1	38,080	203,999	3,348	61.6	105.3	129.5	0.284	1:1.91	225 35	30 32	39,000
144	792.3	17,520	205,267	3,665	57.5	106.9	123.0	0.062	1:1.04	61 40	18 24	17,700
145	796.0	21,120	192,007	2,953	65.4	108.7	127.7	0.251	1:1.04	61 00	15 10	21,200
146	802.0	41,340	191,345	3,271	61.4	86.9	97.4	0.196	1:1.27	118 30	14 48	42,300
147	807.5	17,460	191,388	3,266	59.1	93.8	107.4	0.323	1:1.21	115 00	35 16	17,200
148	810.4	13,720	205,429	2,891	71.2	111.9	128.6	0.331	1:1.20	142 30	50 11	15,000
149	814.9	33,080	177,326	3,624	50.0	82.1	96.9	0.134	1:1.31	158 45	24 48	33,800
Chute, Profit Island			38,400	1,080	45.9							
150	819.5	16,360	190,088	3,404	56.1	96.6	116.5	0.175	1:1.27	122 30	37 35	17,200
151	823.1	21,100	186,019	2,948	63.3	115.2	133.2	0.189	1:1.88	179 50	44 44	21,200
152	826.5	14,440	172,719	2,460	70.8	94.2	105.7	0.233	1:1.02	23 30	8 33	14,500
153	828.5	7,460	230,482	2,620	87.5	131.8	143.1	0.240	1:1.17	122 00	82 26	7,800
154	831.7	26,520	177,895	2,651	67.6	90.8	103.4	0.264	1:1.00	0 00	0 00	26,500
155	836.0	18,320	180,011	2,884	63.2	98.1	106.6	0.146	1:1.03	50 20	14 25	18,400
156	840.9	33,080	191,136	3,186	61.0	94.1	113.1	0.236	1:1.78	167 35	26 21	33,600
157	847.2	33,780	191,380	2,850	67.7	101.2	115.1	0.189	1:2.79	186 25	27 49	35,400
158	853.7	35,280	181,988	2,779	66.6	102.3	125.6	0.089	1:2.80	206 55	30 47	35,500
159	858.7	17,620	192,000	3,224	61.1	92.4	107.4	0.158	1:1.01	48 15	13 59	18,200
160	863.0	27,480	192,844	2,622	74.7	102.6	123.5	0.218	1:1.37	122 00	23 01	28,000
161	868.5	30,780	199,017	2,929	70.9	108.3	128.8	0.198	1:2.03	190 10	31 58	31,400
162	874.3	30,420	186,950	3,077	62.5	98.3	112.5	0.102	1:1.11	89 40	15 28	30,600
163	879.7	26,540	200,433	2,965	69.4	101.2	116.0	0.168	1:1.23	108 40	20 37	27,800
164	883.6	14,580	202,125	2,633	77.6	113.8	136.0	0.186	1:1.63	169 00	63 18	14,100
165	886.8	19,180	213,491	3,346	64.8	99.7	115.1	0.168	1:1.10	129 30	35 23	19,300
166	890.7	21,580	200,492	2,359	85.3	122.6	142.9	0.164	1:2.05	201 15	46 22	22,900
167	895.2	26,400	177,056	2,170	81.9	114.5	137.0	0.163	1:1.24	114 00	21 54	27,500
168	899.9	22,600	176,645	2,285	77.9	106.4	123.7	0.163	1:1.16	112 20	25 41	23,100
169	904.5	26,800	186,191	2,564	73.2	100.3	112.5	0.108	1:1.78	140 10	26 27	28,000
170	908.8	18,740	178,723	2,407	74.7	100.0	112.7	0.190	1:1.07	125 50	34 57	19,100
171	912.3	17,820	188,527	2,331	81.1	104.1	111.1	0.090	1:1.01	24 10	7 05	18,000
172	915.7	17,820	177,217	2,406	74.0	96.4	108.3	0.200	1:1.29	123 30	35 30	18,400
173	918.4	11,360	212,042	2,450	86.8	113.4	125.6	0.244	1:1.27	117 00	55 27	11,200
174	921.3	18,340	172,205	2,255	76.5	101.1	115.3	0.080	1:1.03	52 00	14 50	18,500
175	924.3	13,840	157,432	2,006	78.6	104.4	117.8	0.013	1:1.05	75 40	28 33	14,000
176	927.5	20,120	181,500	3,136	59.2	88.2	96.6	0.411	1:1.49	150 50	39 23	20,200
177	931.9	26,120	166,521	2,416	68.3	100.3	115.1	0.149	1:1.19	117 20	23 28	26,400
178	935.8	14,740	156,694	2,741	58.3	85.8	99.7	0.238	1:1.18	113 10	39 34	15,100
179	940.7	37,560	182,902	2,345	77.0	105.5	116.7	0.127	1:1.15	167 00	23 12	38,000
180	947.3	31,980	163,276	2,490	66.4	96.2	110.0	0.206	1:1.30	150 10	24 01	33,000
181	952.3	20,420	170,382	2,521	69.2	98.1	109.4	0.102	1:1.42	133 10	32 43	21,500
182	956.1	19,920	183,603	2,582	72.1	100.1	118.6	0.164	1:1.76	158 20	38 54	21,500
183	960.2	23,320	179,414	2,463	74.3	100.7	114.3		1:3.22	136 50	28 59	24,900
184	964.0	17,420	172,327	2,052	84.0	102.9	115.4		1:1.15	102 00	30 49	17,500
185	967.9	22,920	195,138	2,287	86.7	107.3	120.8		1:1.22	155 40	33 59	24,200
186	971.6	16,440	158,639	2,391	66.6	89.3	97.3		1:1.02	56 30	18 24	16,200

Revised table of regimen of the Mississippi River, at bank-full stage, from Cairo to the Gulf of Mexico—Continued.

Number of section.	Distance from Cairo.	Length of section.	Mean area.	Mean width.	Mean depth.	Mean thalweg depth.	Mean maximum depth.	Slope per mile, high water, 1882.	Ratio of curvature.	Curvature in degrees.				Distance on arc.
										Total.		Per mile.		
	Miles.	*Feet.*	*Sq. Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		°	′	°	′	*Feet.*
187	977.3	43,920	164,794	2,399	69.1	93.2	104.0	.....	1:2.73	228	10	26	36	45,300
188	983.2	18,640	173,271	2,249	77.3	103.0	114.8	.....	1:1.21	191	10	50	35	19,900
189	987.0	21,120	143,769	2,288	63.1	86.7	100.4	.....	1:1.02	86	30	21	28	21,300
190	991.6	27,300	144,910	2,387	61.1	84.7	96.7	.....	1:1.13	112	00	21	45	27,200
191	996.7	26,620	151,387	2,192	68.4	90.5	102.7	.....	1:1.03	116	10	22	44	27,000
192	1,001.0	19,000	173,175	2,444	71.6	103.5	117.9	.....	1:1.07	104	30	29	02	19,000
193	1,004.9	21,840	145,385	2,368	61.5	84.8	96.1	.....	1:1.01	33	30	8	02	22,000
194	1,009.2	23,900	146,509	2,471	59.9	86.4	101.8	.....	1:1.02	72	10	15	56	24,000
195	1,015.0	37,060	163,114	2,600	64.6	92.4	110.0	.....	1:1.04	167	40	23	33	37,600
196	1,021.2	28,580	145,808	2,298	63.8	89.9	103.7	.....	1:1.07	77	10	13	54	29,300
197	1,025.8	20,120	164,056	2,302	72.4	103.9	117.0	.....	1:1.19	114	40	29	28	20,500
198	1,030.8	32,580	151,740	2,438	62.4	89.9	104.5	.....	1:1.11	93	30	14	49	33,300
199	1,035.2	13,860	169,750	2,702	62.6	96.3	107.7	.....	1:1.01	27	30	10	08	14,100
200	1,037.6	11,360	180,819	2,206	83.4	116.4	131.9	.....	1:1.13	104	30	43	22	12,700
201	1,040.6	20,320	191,020	2,480	78.4	109.6	125.8	.....	1:1.12	101	30	25	38	20,900
202	1,044.1	17,020	154,486	2,512	61.5	80.9	86.6	.....	1:1.01	28	00	8	35	17,200
203	1,048.2	26,020	161,000	2,680	60.1	83.6	92.3	.....	1:1.02	30	00	5	58	26,500
204	1,053.3	27,180	163,500	3,350	50.0	69.8	79.8	.....	1:1.03	37	00	7	06	27,500
205	1,057.6	18,640	175,960	5,801	31.2	42.4	44.6	.....	1:1.03	27	00	7	55	18,000
South West Pass	1,066.5	75,900	63,170	1,388	45.9	60.5	67.9	.....	1:1.01	60	30	4	13	75,900
Pass à l'Outre	1,064.3	26,400	70,192	2,144	34.3	50.0	59.9	.....	1:1.05	105	30	21	06	26,400
South Pass	1,065.0	60,720	19,855	683	29.4	33.0	42.3	.....	1:1.03	109	30	9	30	60,720

Mean regimen elements of the Mississippi River, bank-full stage; Cairo to the Head of the Passes.

From—	To—	Distance from Cairo.	Mean water area of cross-section.	Mean width.	Mean depth.	Mean thalweg depth.	Mean maximum depth.	Mean curvature per mile.
		Miles.	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	° ′
Cairo	New Madrid	65.3	214,022	5,512	55.5	66.4	75.0	21 32
New Madrid	Plum Point	160.8	210,745	5,712	50.2	61.8	67.7	24 34
Plum Point	Memphis	231.0	199,894	5,682	60.9	66.1	73.9	26 33
Memphis	Helena	302.2	195,831	5,876	37.6	57.5	63.2	28 07
Helena	Arkansas River	398.3	190,746	4,563	55.4	74.3	81.2	24 44
Arkansas River	Greenville	476.3	196,901	4,555	53.1	81.2	86.1	27 04
Greenville	Lake Providence	538.0	198,720	4,758	51.5	73.8	81.6	22 01
Lake Providence	Vicksburg	599.4	194,954	4,675	58.0	81.6	85.6	26 06
Vicksburg	Natchez	698.5	203,356	4,526	49.0	85.0	91.7	31 16
Natchez	Red River	759.6	212,192	4,030	56.1	92.0	101.3	26 41
Red River	Baton Rouge	831.7	199,960	3,260	66.5	100.3	114.6	28 23
Baton Rouge	New Orleans	967.9	184,189	2,605	72.4	101.5	116.9	29 31
New Orleans	Head of Passes	1,057.6	161,155	2,628	64.4	90.3	101.8	20 15

ADDITIONAL REPORT OF ASSISTANT ENGINEER L. C. JONES.

CAPTAIN: I have the honor to submit herewith my report upon the "table of means," which was begun in February, 1884, in accordance with instructions from Lieut. Smith S. Leach, who furnished me with the following resolution of the committee on surveys and examinations, November 19, 1883:

"That the secretary furnish for the use of the committee a table showing the mean width, mean depth, and mean channel depths for each 2 miles of river at a medium stage of water."

The stage of water selected by me was that of mean stage for the year 1882, there being full data at all the principal gauges.

From the data I obtained the general slope per mile at medium stage between gauges, and could by this means compute the elevation of mean stage for any given section.

Having already computed and plotted the cross-sections for bank-full stage for the "high-water regimen," the cross-sections at medium stage could be determined by simple subtraction.

When the work had been finished to Memphis I received orders to extend the "table of means" by showing the same elements of cross-sections at a bank-full stage, and in this portion of the work used the cross-sections as measured for the "high-water regimen."

The planimeter was used to measure the cross-section area, which, divided by the width, gave the mean depth. The width and channel depth were measured with a scale.

The river was divided into 2-mile divisions, the upper end of the first division being 2 miles below Cairo, the origin of distance.

The means of the three elements, in all the cross-sections embraced in each 2 miles, were taken, and are the values given in the tabulation. New values for the means were obtained from the new surveys, and extend from Cairo to Old Hen Island from Commerce Cut-off to St. Louis Landing, Arkansas.

Very respectfully, your obedient servant,

L. C. JONES,
Assistant Engineer.

To Capt. THOMAS TURTLE,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission.

Mean widths, mean depths, and means of maximum depths of 2-mile sections of main river from Cairo, Illinois, to Head of Passes.

No. of section.	Distance from Cairo.	Medium stage.			Bank-full stage.		
		Mean width.	Mean depth.	Mean of maximum depth.	Mean width.	Mean depth.	Mean of maximum depth.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1							
2							
3							
4							
5	10	4,707	29.8	59.1	4,826	42.2	70.2
6	12	4,380	30.1	58.8	4,874	40.6	71.7
7	14	5,138	22.9	73.2	7,257	30.1	86.9
8	16	3,968	31.8	63.1	4,161	44.5	76.9
9	18	3,518	38.7	56.2	3,660	50.6	69.2
10	20	2,694	61.3	101.4	2,830	71.4	115.0
11	22	6,008	26.2	62.2	6,110	39.0	75.2
12	24	4,221	30.6	53.0	4,353	42.7	66.0
13	26	4,281	27.9	46.4	4,577	39.5	59.3
14	28	4,598	32.1	48.3	4,755	42.3	59.4
15	30	5,996	26.3	62.2	6,172	37.6	74.2
16	32	4,789	31.2	63.3	5,274	40.4	75.0
17	34	4,845	28.2	94.9	4,944	40.9	108.2
18	36	2,800	49.8	81.9	3,625	50.9	94.9
19	38	4,522	37.2	50.3	4,609	48.7	62.6
20	40	4,788	32.7	62.2	4,860	43.8	74.6
21	42	4,688	31.3	55.6	4,768	43.1	65.4
22	44	4,301	30.8	56.3	4,404	43.7	69.8
23	46	4,289	26.9	74.8	4,473	37.8	86.0
24	48	2,933	40.2	72.9	3,074	49.7	83.8
25	50	4,043	35.4	57.4	4,094	46.2	68.7
26	52	5,843	28.6	44.8	5,794	41.0	56.6
27	54	4,920	31.9	64.3	5,063	42.8	76.2
28	56	4,646	31.1	64.5	4,841	42.3	76.5
29	58	7,170	22.5	48.5	9,795	28.9	61.1
30	60	5,058	28.5	56.5	7,280	31.2	68.0
31	62	4,819	28.6	55.6	5,547	37.5	67.3
32	64	4,431	28.4	65.9	5,738	33.3	77.2
33	66	5,060	29.1	51.9	5,334	38.5	62.6
34	68	5,694	25.2	53.5	6,620	33.2	63.9
35	70	4,932	25.7	65.8	5,045	39.4	77.3
36	72	5,779	27.7	42.7	6,057	37.4	55.1
37	74	5,828	24.5	47.0	5,983	38.2	60.5
38	76	7,061	21.4	39.3	7,743	34.7	53.7
39	78	7,319	24.2	47.0	7,499	39.7	62.4
40	80	4,583	29.1	73.8	5,847	37.4	89.5
41	82	4,271	32.1	54.3	4,849	44.5	70.9
42	84	5,657	25.5	46.8	5,873	41.5	63.2
43	86	4,294	29.6	56.6	4,711	41.5	71.1
44	88	5,011	28.2	50.7	6,527	35.8	64.1
45	90	4,080	29.1	65.5	7,650	30.1	83.1
46	92	3,106	37.3	70.5	6,103	32.6	83.9
47	94	4,018	34.2	58.0	4,678	42.6	73.0
48	96	5,290	25.8	56.4	5,397	40.5	72.3
49	98	4,823	27.9	55.6	5,337	40.6	70.2
50	100	4,611	29.1	51.8	4,804	43.6	65.7
51	102	4,398	29.4	60.4	4,605	43.1	69.9
52	104	3,290	33.9	75.3	6,095	31.5	89.4
53	106	2,938	40.3	70.3	4,975	38.2	84.0
54	108	3,998	33.2	50.7	4,129	45.0	62.4
55	110	4,521	30.2	47.3	4,579	42.8	59.9
56	112	5,583	25.6	43.7	5,694	39.6	57.5
57	114	5,092	26.3	55.2	5,156	40.5	68.7
58	116	3,873	32.0	58.3	3,965	46.5	72.3
59	118	5,173	26.9	45.1	5,139	41.7	60.3
60	120	2,510	28.2	50.3	3,207	41.9	68.9
61	122	4,996	28.0	43.4	5,100	43.5	60.2
62	124	4,858	22.5	53.0	5,644	35.2	69.1
63	126	3,705	29.9	47.8	3,990	45.2	64.8
64	128	4,404	26.9	36.6	4,465	43.6	52.8
65	130	4,785	25.1	46.5	4,942	40.7	62.2
66	132	3,970	29.6	52.1	4,272	43.6	67.5
67	134	4,080	30.0	57.3	5,087	41.0	73.3
68	136	3,577	28.5	64.4	5,709	32.5	79.8
69	138	3,232	35.5	56.7	3,904	45.3	71.8
70	140	4,160	24.5	63.1	4,864	35.6	78.1
71	142	3,002	34.9	63.6	4,020	40.4	78.3
72	144	4,016	27.8	46.9	4,141	44.3	62.8
73	146	3,075	28.8	55.8	4,006	38.4	71.3

Mean widths, mean depths, and means of maximum depths of 2-mile sections of main river from Cairo, Illinois, to Head of Passes—Continued.

No. of section.	Distance from Cairo.	Medium stage.			Bank-full stage.		
		Mean width	Mean depth.	Mean of maximum depth.	Mean width.	Mean depth.	Mean of maximum depth.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
74	148	4,380	24.1	50.0	4,960	37.5	65.9
75	150	2,611	31.2	56.1	4,286	31.5	70.9
76	152	4,312	24.7	50.6	5,306	34.7	64.9
77	154	3,913	27.1	51.9	4,019	41.5	66.0
78	156	5,142	24.8	38.4	5,859	38.4	53.2
79	158	6,149	17.9	40.1	8,167	29.0	55.1
80	160	5,971	20.3	38.7	6,736	33.4	53.7
81	162	6,726	19.6	44.7	7,710	32.1	50.8
82	164	5,302	24.0	42.8	4,326	43.1	59.0
83	166	7,924	17.9	34.8	7,191	31.8	50.1
84	168	4,896	26.4	49.9	6,864	33.6	66.3
85	170	4,164	31.5	49.4	5,920	39.2	66.1
86	172	2,959	47.4	84.3	3,353	59.4	101.0
87	174	2,651	46.0	60.8	2,813	60.7	77.8
88	176	4,888	26.3	38.1	5,044	43.8	55.8
89	178	5,033	24.8	40.7	5,025	42.2	57.6
90	180	4,948	26.1	46.7	5,046	43.3	63.7
91	182	3,701	37.4	84.0	4,037	51.1	101.6
92	184	2,335	55.2	89.4	2,539	69.3	107.5
93	186	3,264	27.9	61.3	3,981	40.9	78.4
94	188	4,130	22.9	49.3	4,376	37.2	64.5
95	190	4,693	18.6	51.5	5,454	32.6	67.6
96	192	2,993	28.3	51.2	4,248	34.7	67.8
97	194	3,380	26.9	45.1	3,653	42.8	62.1
98	196	3,793	29.4	53.5	4,218	44.2	72.2
99	198	4,502	26.6	52.9	4,713	45.1	71.5
100	200	4,693	25.2	58.4	5,548	38.5	75.8
101	202	3,266	31.9	62.3	3,908	41.8	77.8
102	204	3,067	29.2	57.5	3,722	40.1	73.7
103	206	4,109	25.1	42.6	4,245	40.6	58.4
104	208	1,971	51.6	80.2	2,097	64.1	90.8
105	210	3,586	38.4	77.8	4,084	47.5	84.2
106	212	6,519	17.1	41.7	6,872	30.1	56.3
107	214	5,313	21.6	46.0	6,907	31.8	60.9
108	216	2,986	28.3	54.1	6,638	26.2	69.3
109	218	3,373	27.0	55.2	4,862	35.8	71.0
110	220	4,089	28.2	50.8	4,200	43.9	66.6
111	222	4,836	24.9	60.5	5,586	36.1	75.4
112	224	4,085	32.4	58.0	4,540	41.3	62.9
113	226	3,278	36.6	81.0	4,750	34.1	76.8
114	228	2,650	41.0	69.2	3,285	45.7	79.2
115	230	2,793	38.9	79.3	2,995	44.7	88.9
116	232	4,070	27.4	46.3	4,327	33.9	56.8
117	234	3,553	17.4	38.7	5,540	23.5	51.0
118	236	4,127	16.3	36.3	4,950	26.2	48.3
119	238	3,653	20.2	38.0	3,800	32.5	50.5
120	240	4,912	22.2	39.0	5,192	35.0	51.5
121	242	5,397	23.9	40.7	5,467	37.8	52.3
122	244	4,930	23.7	41.7	5,073	36.1	53.8
123	246	4,278	27.3	46.5	4,962	36.1	60.2
124	248	4,667	21.8	47.0	6,410	29.5	60.3
125	250	2,470	33.0	46.8	3,565	37.9	61.9
126	252	3,408	29.0	43.0	3,555	43.1	58.7
127	254	5,137	20.2	37.3	5,313	35.9	53.8
128	256	3,673	24.2	37.7	4,123	32.8	50.6
129	258	4,698	24.3	35.8	5,005	35.2	48.3
130	260	3,780	20.0	33.0	3,953	32.5	46.7
131	262	3,733	22.0	33.0	4,737	27.9	42.7
132	264	3,893	21.5	32.0	5,383	25.5	42.1
133	266	3,807	20.2	32.0	5,387	25.4	43.4
134	268	5,007	22.4	36.7	6,177	30.1	49.0
135	270	6,447	21.2	52.0	7,220	31.4	64.2
136	272	6,047	21.5	57.7	8,253	24.7	67.7
137	274	4,000	32.2	66.6	5,140	37.1	79.4
138	276	3,922	25.1	69.8	8,349	24.6	83.7
139	278	4,110	27.8	52.5	5,902	33.5	67.2
140	280	3,781	31.1	59.8	4,204	39.5	73.0
141	282	5,286	25.8	51.0	5,598	37.7	64.0
142	284	4,384	28.5	62.6	4,812	39.8	75.6
143	286	2,999	36.7	71.6	4,330	38.6	85.4
144	288	6,041	23.1	47.9	6,640	35.4	61.9
145	290	3,866	29.2	61.8	4,703	39.2	76.2
146	292	5,730	25.9	52.0	5,783	41.9	66.3

Mean widths, mean depths, and means of maximum depths of 2-mile sections of main river from Cairo, Illinois, to Head of Passes—Continued.

No. of section.	Distance from Cairo.	Medium stage.			Bank-full stage.		
		Mean width.	Mean depth.	Mean of maximum depth.	Mean width.	Mean depth.	Mean of maximum depth.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
147	294	6,806	20.4	52.8	7,322	34.4	68.2
148	296	4,567	28.1	59.5	6,248	35.8	74.6
149	298	4,272	32.3	68.8	4,496	47.6	84.5
150	300	4,834	34.3	54.3	4,586	50.7	70.0
151	302	7,539	19.8	58.4	9,256	32.0	75.3
152	304	4,051	33.3	78.7	5,387	42.0	93.6
153	306	4,653	29.5	61.5	4,865	45.1	77.0
154	308	4,829	27.8	60.9	5,417	40.7	76.2
155	310	3,806	37.9	63.8	4,629	46.4	71.6
156	312	6,418	25.3	61.5	7,398	35.2	85.0
157	314	3,153	42.0	94.2	4,175	45.3	108.8
158	316	5,034	30.7	52.9	5,135	46.1	68.3
159	318	3,834	35.2	74.1	4,154	45.8	76.6
160	320	3,515	39.2	62.9	3,836	49.1	76.0
161	322	3,241	37.6	71.7	3,528	48.2	84.9
162	324	2,820	41.6	95.2	3,619	45.4	107.7
163	326	3,152	37.2	83.3	3,513	45.4	95.8
164	328	4,246	28.8	55.8	4,302	42.6	69.1
165	330	5,475	19.1	65.4	6,087	31.2	79.6
166	332	3,421	32.6	66.0	3,790	43.9	78.1
167	334	4,486	30.8	56.6	4,580	44.1	69.9
168	336	3,959	30.6	60.7	4,070	43.7	74.7
169	338	3,398	36.8	75.0	3,671	49.2	88.9
170	340	3,636	32.8	73.8	4,171	41.4	86.8
171	342	4,987	29.7	65.5	6,027	37.8	78.6
172	344	3,677	32.7	78.0	5,234	32.8	89.9
173	346	2,977	36.6	74.5	4,454	36.6	88.1
174	348	3,137	35.6	56.3	3,225	46.4	67.7
175	350	4,488	25.6	65.2	4,544	35.8	75.6
176	352	3,583	28.1	63.3	3,890	37.4	75.0
177	354	2,908	34.9	70.0	3,110	44.4	81.9
178	356	3,140	39.3	61.0	3,188	51.7	73.3
179	358	4,188	32.2	53.6	4,282	44.9	67.0
180	360	5,430	25.8	51.4	5,104	37.6	64.8
181	362	2,680	24,1	63.2	3,392	39.2	76.0
182	364	2,452	39.1	67.2	2,716	52.0	80.8
183	366	3,756	33.6	51.4	3,818	48.3	66.4
184	368	4,002	28.7	55.8	4,088	44.3	72.1
185	370	3,510	32.1	69.0	3,658	43.9	82.3
186	372	2,514	47.5	90.4	2,902	53.7	103.9
187	374	3,324	34.4	86.0	3,816	43.7	100.1
188	376	3,548	38.1	65.0	3,888	49.5	80.4
189	378	4,194	28.2	72.6	6,010	36.2	90.8
190	380	2,818	41.2	68.6	3,364	49.7	83.8
191	382	4,390	29.5	50.4	4,836	40.6	64.2
192	384	4,493	28.6	53.5	4,925	39.7	66.8
193	386	2,715	38.4	79.2	3,113	46.7	93.5
194	388	2,935	42.2	59.5	3,042	54.2	74.0
195	390	4,572	28.4	64.0	4,704	42.5	79.1
196	392	3,497	37.6	69.5	3,808	47.0	84.5
197	394	2,612	46.8	86.0	3,662	47.7	101.5
198	396	3,410	40.4	64.5	3,900	50.9	80.7
199	398	3,998	33.4	65.0	4,415	47.2	80.8
200	400	3,158	42.1	70.2	3,282	54.5	83.3
201	402	3,432	36.4	67.5	3,675	45.4	81.2
202	404	3,330	40.3	79.2	4,032	44.5	95.0
203	406	3,410	48.0	93.2	3,944	56.4	108.5
204	408	2,154	55.4	99.6	3,906	42.1	114.1
205	410	2,984	41.7	66.8	3,674	47.4	80.1
206	412	4,015	33.4	55.5	4,152	48.1	70.5
207	414	3,788	29.3	54.4	5,094	33.3	68.0
208	416	2,407	47.3	89.3	4,007	40.1	102.6
209	418	3,597	38.8	62.0	3,982	51.1	75.4
210	420	4,848	29.2	65.7	5,313	38.9	78.3
211	422	4,256	33.1	70.8	4,282	47.1	85.9
212	424	5,280	26.6	89.6	5,932	37.6	104.7
213	426	3,272	38.3	86.2	3,966	45.5	100.7
214	428	3,040	43.6	92.8	3,302	55.1	107.8
215	430	3,090	44.3	69.2	3,322	56.8	85.6
216	432	4,267	34.4	54.3	4,660	47.0	69.5
217	434	5,845	26.4	43.5	7,862	32.9	58.4
218	436	3,496	43.3	77.2	3,694	55.9	92.9
219	438	3,458	47.7	80.6	3,610	60.6	95.9
220	440	2,573	51.4	95.0	3,627	50.7	111.0

Mean widths, mean depths, and means of maximum depths of 2-mile sections of main river from Cairo, Illinois, to Head of Passes—Continued.

No. of section.	Distance from Cairo.	Medium stage.			Bank-full stage.		
		Mean width.	Mean depth.	Mean of maximum depth.	Mean width.	Mean depth.	Mean of maximum depth.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
221	442	2,467	51.7	78.7	2,817	60.8	94.6
222	444	3,418	30.1	61.5	6,623	30.3	78.3
223	446	4,111	31.8	57.9	4,660	45.1	75.7
224	448	3,813	38.2	75.0	4,396	50.5	93.3
225	450	2,961	40.4	84.7	3,674	48.4	100.4
226	452	2,554	46.5	77.4	2,814	57.7	94.7
227	454	3,520	36.7	58.7	3,924	48.7	75.0
228	456	4,046	29.4	65.4	5,183	39.3	83.0
229	452	3,400	34.1	76.4	3,713	49.1	94.6
230	460	3,399	35.8	72.0	3,858	46.0	87.6
231	462	3,365	37.3	61.3	3,542	49.6	75.4
232	464	4,723	29.6	61.4	4,789	47.1	79.3
233	466	4,562	28.2	74.5	5,243	40.6	90.7
234	468	2,649	44.2	81.9	3,053	56.3	100.2
235	470	2,687	42.6	73.4	3,237	52.4	91.5
236	472	3,477	36.1	49.5	3,618	53.2	67.5
237	474	4,184	26.4	64.1	4,584	40.3	80.4
238	476	3,878	29.6	65.3	4,947	39.2	82.4
239	478	3,584	34.3	59.0	4,150	45.5	76.0
240	480	3,905	33.1	49.5	4,487	43.4	64.0
241	482	5,417	27.7	50.3	5,493	46.1	68.5
242	484	4,755	55.9	57.0	4,970	40.7	72.5
243	486	5,446	24.8	43.8	6,124	37.9	60.6
244	488	4,102	29.2	58.7	5,078	41.8	72.0
245	490	3,847	31.8	57.5	4,135	47.8	75.5
246	492	3,380	35.2	58.6	4,920	40.4	57.5
247	494	3,240	43.8	71.2	3,885	54.3	89.2
248	496	2,443	44.9	78.0	3,640	47.2	95.8
249	498	3,373	33.9	72.2	4,447	38.7	86.3
250	500	4,077	30.3	57.0	4,447	42.2	72.0
251	502	4,140	30.4	49.7	4,237	45.6	65.8
252	504	4,157	27.4	56.2	5,212	38.0	72.4
253	506	3,473	30.9	65.7	5,727	32.6	81.6
254	508	2,993	35.6	84.3	5,220	33.8	98.3
255	510	3,706	33.4	70.2	3,826	46.6	84.8
256	512	4,015	32.4	62.0	5,100	40.8	27.0
257	514	3,682	32.5	56.7	4,865	39.0	70.9
258	516	3,615	34.0	68.0	3,908	46.0	79.8
259	518	3,254	38.3	72.2	3,798	47.4	86.9
260	520	3,360	44.4	91.7	3,540	56.4	106.5
261	522	2,873	43.4	97.7	3,313	52.9	112.4
262	524	3,992	31.1	50.0	4,055	46.6	66.1
263	526	4,617	27.8	57.5	4,762	42.8	73.3
264	528	4,823	29.6	47.7	5,713	37.5	61.7
265	530	3,908	36.9	65.0	4,507	43.3	79.2
266	532	4,750	29.2	54.3	5,128	41.5	68.7
267	534	4,423	30.8	62.7	4,500	45.7	78.0
268	536	4,220	29.5	80.7	5,070	38.7	95.7
269	538	6,250	24.1	46.0	7,173	36.6	62.3
270	540	4,550	29.4	63.8	5,580	38.5	79.6
271	542	4,365	29.4	77.8	5,012	40.9	76.7
272	544	5,725	25.5	49.5	6,255	38.7	64.5
273	246	5,575	24.5	67.0	7,330	30.3	77.7
274	248	3,554	36.4	80.4	4,340	44.1	95.0
275	550	2,225	40.4	66.0	2,918	41.8	79.5
276	552	2,596	42.7	78.2	2,964	50.9	92.6
277	554	3,630	33.1	64.5	4,658	40.4	78.7
278	556	3,976	29.1	48.2	4,926	37.2	63.5
279	558	2,910	35.5	75.6	4,476	38.1	91.5
280	560	2,107	41.9	91.0	3,553	37.4	105.0
281	562	2,473	43.9	79.5	3,479	42.4	86.0
282	564	4,026	29.2	48.0	4,436	40.5	62.7
283	566	4,820	25.0	51.8	5,408	38.2	70.0
284	568	5,012	22.9	57.5	7,040	31.9	74.3
285	570	4,180	27.0	67.0	5,580	34.4	81.9
286	572	3,158	39.7	75.4	3,630	50.4	91.4
287	574	2,510	45.9	97.6	4,264	39.7	112.1
288	576	3,120	32.6	64.3	3,445	45.1	79.5
289	578	2,353	48.3	79.0	2,817	51.6	91.8
290	580	4,488	31.6	61.4	4,634	44.2	76.3
291	582	4,006	30.7	52.6	4,274	45.9	69.9
292	584	3,427	37.4	46.8	3,505	47.3	65.0
293	586	3,451	37.6	64.1	3,738	47.6	76.6
294	588	1,812	53.4	74.5	1,810	67.6	88.9

Mean widths, mean depths, and means of maximum depths of 2-mile sections of main river from Cairo, Illinois, to Head of Passes—Continued.

No. of section.	Distance from Cairo.	Medium stage.			Bank-full stage.		
		Mean width.	Mean depth.	Mean of maximum depth.	Mean width.	Mean depth.	Mean of maximum depth.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
295	590	3,416	40.4	72.6	3,470	54.5	87.7
296	592	2,996	40.0	93.0	3,490	50.9	108.4
297	594	3,532	43.1	73.3	3,615	58.5	89.7
298	596	3,560	39.0	78.8	3,807	51.8	94.2
299	598	3,138	52.5	108.3	3,807	60.8	120.8
300	600	3,645	41.4	73.0	4,108	48.7	86.1
301	602	3,665	30.6	85.8	5,705	36.4	99.0
302	604	5,722	31.9	52.2	6,198	45.0	66.4
303	606	3,223	34.9	64.7	4,630	40.7	81.0
304	608	3,626	31.8	61.0	4,172	42.9	76.1
305	610	3,826	34.7	58.8	4,258	45.3	74.5
306	612	3,790	24.4	60.4	5,210	38.7	74.2
307	614	3,510	33.9	62.7	5,260	35.2	76.6
308	616	3,860	36.0	64.2	4,140	49.8	77.2
309	618	3,650	33.7	69.8	5,390	36.1	85.1
310	620	3,330	38.4	63.9	4,900	42.3	78.6
311	622	5,240	26.6	68.3	5,820	40.0	84.5
312	624	3,710	38.8	77.7	4,810	44.2	93.8
313	626	2,860	42.5	79.1	3,770	44.1	91.6
314	628	3,290	42.7	71.0	3,720	51.8	85.0
315	630	3,040	38.3	69.6	3,950	39.9	82.9
316	632	3,920	31.9	77.0	4,330	39.0	87.3
317	634	3,160	42.3	81.2	4,410	41.3	91.9
318	636	3,870	37.7	71.7	4,570	42.5	83.1
319	638	3,480	31.5	81.3	3,940	41.3	94.8
320	640	3,660	39.6	69.8	3,970	49.7	84.1
321	642	5,470	27.8	67.8	6,110	39.8	84.3
322	644	4,150	35.7	53.6	4,220	48.6	67.0
323	646	3,730	38.7	53.7	3,860	52.4	68.2
324	648	3,130	45.6	99.8	3,800	50.6	113.8
325	650	3,400	48.8	88.8	3,890	57.1	103.8
326	652	2,430	51.9	103.9	3,400	49.1	118.4
327	654	3,790	40.9	74.6	4,130	52.1	91.1
328	656	7,870	21.3	70.6	7,940	37.4	87.2
329	658	5,350	29.8	64.0	5,760	43.8	80.1
330	660	4,160	31.8	56.7	4,980	43.4	72.9
331	662	4,970	26.7	72.4	5,660	38.0	87.2
332	664	3,040	37.5	78.6	3,730	42.7	92.6
333	666	2,460	46.0	83.2	2,660	56.8	35.2
334	668	4,120	36.7	66.4	4,210	51.9	82.2
335	670	3,440	44.9	90.6	3,470	59.8	105.9
336	672	2,300	57.3	108.1	2,420	69.4	123.2
337	674	3,850	44.3	81.7	3,940	58.6	98.9
338	676	4,820	32.6	83.2	4,890	50.0	99.9
339	678	5,960	31.3	68.8	6,090	46.1	84.6
340	680	4,060	36.4	87.8	4,680	43.5	101.4
341	682	3,760	41.4	88.5	4,350	50.7	103.9
342	684	3,590	41.1	62.9	3,760	55.5	79.2
343	686	4,380	33.0	94.6	4,570	46.6	111.3
344	688	3,080	50.7	91.8	3,720	56.2	107.1
345	690	3,710	40.0	79.7	3,990	52.0	94.4
346	692	2,760	45.7	99.6	4,360	42.4	113.5
347	694	3,350	44.3	92.8	3,920	50.8	106.4
348	696	2,990	55.8	111.7	3,710	61.6	128.8
349	698	2,580	54.8	119.2	3,800	53.7	137.1
350	700	2,360	56.5	90.0	2,510	71.8	108.3
351	702	2,890	44.8	57.3	2,970	62.4	76.0
352	704	4,420	33.5	58.9	4,660	51.0	77.8
353	706	5,310	28.2	49.6	5,460	45.5	68.1
354	708	3,710	38.7	59.4	3,780	56.3	78.0
355	710	5,530	28.2	55.6	5,860	42.8	72.1
356	712	5,330	27.8	64.0	5,940	41.9	78.8
357	714	2,430	60.3	98.8	2,630	71.2	113.9
358	716	2,490	52.7	106.0	3,010	59.9	121.7
359	718	3,840	39.4	73.9	4,270	53.5	89.3
360	720	3,320	36.7	73.3	6,170	38.9	89.9
361	722	3,950	31.5	63.6	7,400	37.3	79.6
362	724	3,330	37.6	67.9	6,130	34.6	82.1
363	726	2,340	56.7	100.5	3,420	58.6	115.8
364	728	3,660	37.8	99.6	3,850	52.2	117.8
365	730	4,350	32.4	72.7	4,580	47.8	89.9
366	732	2,960	47.9	96.7	3,250	59.4	113.4
367	734	3,080	44.6	77.1	3,250	58.8	93.9
368	736	3,330	44.1	61.7	3,430	59.5	78.6

Mean widths, mean depths, and means of maximum depths of 2-mile sections of main river from Cairo, Illinois, to Head of Passes—Continued.

No. of section.	Distance from Cairo.	Medium stage.			Bank-full stage.		
		Mean width.	Mean depth.	Mean of maximum depth.	Mean width.	Mean depth.	Mean of maximum depth.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
369	738	4,190	34.3	93.6	4,290	48.0	108.4
370	740	2,510	54.3	104.0	2,850	62.3	119.5
371	742	3,820	39.2	84.9	4,060	53.0	101.3
372	744	3,900	36.9	93.9	4,090	51.3	110.2
373	746	3,220	46.5	102.6	3,350	60.9	119.0
374	748	2,950	46.6	95.6	3,160	60.2	112.3
375	750	3,850	38.6	74.5	3,950	54.2	90.5
376	752	3,290	47.9	102.1	3,350	61.1	117.0
377	754	2,740	69.4	132.8	3,080	76.4	149.6
378	756	2,830	51.0	109.5	3,120	64.0	128.3
379	758	3,750	42.0	75.7	3,790	60.9	94.9
380	760	4,670	34.8	78.3	4,870	50.5	95.2
381	762	3,750	43.7	76.2	3,980	57.1	91.9
382	764	3,960	44.6	64.9	4,010	61.1	82.0
383	766	4,160	38.2	86.8	4,220	53.3	102.7
384	768	2,880	53.1	98.8	2,970	66.1	113.6
385	770	2,980	50.4	83.8	3,030	62.7	96.8
386	772	3,250	45.6	88.5	3,290	61.0	104.2
387	774	2,800	54.0	118.7	3,080	64.8	134.7
388	776	3,180	52.0	80.8	3,270	65.6	95.7
389	778	4,450	33.4	65.2	4,710	49.2	79.7
390	780	3,610	46.7	87.9	3,920	55.6	101.5
391	782	2,650	61.9	112.8	2,990	69.7	127.8
392	784	3,320	50.6	111.4	3,600	63.0	127.5
393	786	2,430	66.2	134.7	2,940	65.6	146.7
394	788	3,300	47.5	107.9	3,466	57.2	120.5
395	790	2,710	58.7	105.6	3,200	60.1	117.0
396	792	3,620	48.3	117.8	4,120	52.8	129.3
397	794	2,800	60.6	123.3	2,910	69.8	135.4
398	796	2,840	53.4	107.6	3,010	60.3	117.2
399	798	4,170	40.3	70.3	4,210	52.0	82.7
400	800	3,350	46.4	97.6	3,490	58.1	111.2
401	802	2,170	64.4	93.9	2,260	75.2	108.0
402	804	2,700	53.8	76.0	2,270	65.7	89.3
403	806	3,310	46.1	87.4	3,470	56.3	100.2
404	808	2,670	63.1	111.9	3,040	67.8	123.7
405	810	2,490	57.1	102.6	2,610	66.5	115.0
406	812	3,580	40.9	81.6	3,870	51.2	94.0
407	814	3,700	36.8	88.4	3,810	47.2	100.4
408	816	2,760	48.5	91.2	2,950	56.1	102.5
409	818	3,360	45.7	104.1	3,520	56.0	116.7
410	820	2,870	55.0	104.3	3,200	59.0	116.6
411	822	2,690	62.2	131.4	3,140	62.3	141.8
412	824	2,320	64.6	112.3	2,520	68.0	121.5
413	826	2,430	63.8	99.3	2,520	73.8	111.7
414	828	2,540	75.0	127.8	2,660	82.7	139.4
415	830	2,400	61.2	90.9	2,470	70.9	102.4
416	832	2,820	52.9	85.6	2,920	62.9	97.7
417	834	2,500	59.8	89.1	2,670	67.6	101.4
418	836	3,040	49.6	96.7	3,150	58.4	107.7
419	838	3,380	44.4	80.6	3,530	53.5	92.0
420	840	2,940	56.8	122.3	3,430	58.8	135.3
421	842	2,340	67.5	109.3	2,650	71.2	121.6
422	844	2,510	59.4	86.7	2,710	66.5	98.0
423	846	2,980	58.8	105.4	3,240	65.3	117.3
424	848	2,180	67.9	123.6	2,490	71.0	135.6
425	850	2,940	52.9	85.7	3,130	61.7	97.8
426	852	2,450	65.5	127.9	2,610	72.2	139.8
427	854	2,590	55.3	112.8	2,780	62.6	125.0
428	856	2,380	69.7	117.7	2,700	70.6	129.1
429	858	3,400	50.3	91.3	3,610	56.5	101.7
430	860	2,570	59.9	89.7	2,760	65.6	99.7
431	862	2,420	75.5	135.1	2,520	83.0	145.6
432	864	2,680	58.6	101.8	2,810	66.9	112.7
433	866	3,620	48.8	118.0	3,720	58.5	129.5
434	868	2,330	76.2	136.5	2,460	82.2	146.9
435	870	2,410	64.0	94.7	2,520	71.5	104.9
436	872	3,400	46.8	91.3	3,540	55.0	101.1
437	874	2,440	67.1	116.3	2,800	68.0	126.4
438	876	2,760	56.2	96.8	3,030	60.5	106.6
439	878	2,620	57.1	77.6	2,720	65.0	87.6
440	880	2,620	76.3	129.7	3,050	74.7	139.5
441	882	2,590	68.4	127.0	2,800	73.8	138.3

Mean widths, mean depths, and means of maximum depths of 2-mile sections of main river from Cairo, Illinois, to Head of Passes—Continued.

No. of section.	Distance from Cairo.	Medium stage.			Bank-full stage.		
		Mean width.	Mean depth.	Mean of maximum depth.	Mean width.	Mean depth.	Mean of maximum depth.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
442	884	2,460	73.9	122.3	2,580	80.8	132.7
443	886	3,010	58.6	97.3	3,380	61.2	107.3
444	888	2,600	74.3	126.0	3,030	73.1	137.8
445	890	2,330	87.2	149.8	2,400	94.9	158.8
446	892	2,120	73.2	113.0	2,170	80.2	121.1
447	894	2,130	72.6	129.2	2,180	80.4	137.2
448	896	2,110	80.2	147.0	2,190	85.2	155.0
449	898	2,080	76.9	131.7	2,170	82.0	139.7
450	900	2,350	65.8	96.4	2,440	72.0	104.4
451	902	2,430	63.1	96.9	2,480	69.8	104.4
452	904	2,430	75.5	125.1	2,480	81.2	132.1
453	906	2,720	59.2	95.6	2,780	65.3	102.6
454	908	2,360	69.2	109.6	2,410	74.7	116.6
455	910	2,161	77.1	111.6	2,199	83.0	118.2
456	912	2,407	73.1	96.7	2,447	78.4	103.8
457	914	2,399	68.3	99.9	2,434	72.8	105.9
458	916	2,443	71.5	111.3	2,462	76.5	117.3
459	918	2,343	80.6	114.6	2,360	85.3	120.4
460	920	2,241	71.9	111.6	2,261	76.3	115.4
461	922	2,140	74.4	108.4	2,163	78.1	113.4
462	924	2,056	72.6	112.1	2,093	75.0	117.1
463	926	2,971	63.2	99.1	3,001	66.6	104.1
464	928	3,170	54.8	98.6	3,354	56.3	102.6
465	930	2,376	69.8	116.7	2,438	71.3	120.8
466	932	2,184	60.1	98.7	2,224	62.0	102.7
467	934	2,412	59.4	95.2	2,456	61.1	99.2
468	936	2,840	79.1	136.6	2,921	80.2	140.4
469	938	2,399	67.3	106.7	2,424	69.5	109.7
470	940	2,255	69,9	97.3	2,275	71.9	100.3
471	942	2,147	74.1	100.9	2,164	76.2	112.9
472	944	2,663	60.3	99.8	2,675	63.1	102.8
473	946	2,651	62.7	104.2	2,669	64.9	106.9
474	948	2,191	64.6	115.9	2,217	66.1	117.9
475	950	2,124	74.6	118.9	2,146	78.1	120.9
476	952	2,630	66.8	104.3	2,650	68.1	106.3
477	954	2,878	61.1	94.4	2,886	62.5	96.4
478	956	2,397	76.8	132.0	2,404	78.0	133.7
479	958	.....	.....	.....	2,391	81.1	125.4
480	960	.....	.....	.....	2,666	65.5	101.3
481	962	.....	.....	.....	2,072	77.9	109.2
482	964	.....	.....	.....	2,039	90.2	124.6
483	966	.....	.....	.....	2,152	98.4	147.7
484	968	.....	.....	.....	2,438	71.9	91.9
485	970	.....	.....	.....	2,420	67.0	94.4
486	972	.....	.....	.....	2,543	63.0	103.7
487	974	.....	.....	.....	2,376	68.4	108.1
488	976	.....	.....	.....	2,484	65.9	95.4
489	978	.....	.....	.....	2,423	72.5	113.6
490	980	.....	.....	.....	2,313	74.0	109.8
491	982	.....	.....	.....	2,231	80.5	118.1
492	984	.....	.....	.....	2,268	64.4	93.3
493	986	.....	.....	.....	2,200	65.8	102.9
494	988	.....	.....	.....	2,426	60.5	93.5
495	990	.....	.....	.....	2,417	58.8	93.3
496	992	.....	.....	.....	2,278	64.0	98.7
497	994	.....	.....	.....	2,429	61.2	94.4
498	996	.....	.....	.....	2,163	73.1	104.0
499	998	.....	.....	.....	2,204	75.6	125.0
500	1,000	.....	.....	.....	2,427	75.3	124.3
501	1,002	.....	.....	.....	2,492	60.0	82.7
502	1,004	.....	.....	.....	2,292	62.9	100.3
503	1,006	.....	.....	.....	2,462	57.7	100.2
504	1,008	.....	.....	.....	2,586	56.3	105.1
505	1,010	.....	.....	.....	2,461	62.8	99.4
506	1,012	.....	.....	.....	2,837	55.2	101.7
507	1,014	.....	.....	.....	2,237	85.2	140.1
508	1,016	.....	.....	.....	2,717	56.8	100.4
509	1,018	.....	.....	.....	2,380	61.3	91.6
510	1,020	.....	.....	.....	2,342	64.3	107.4
511	1,022	.....	.....	.....	2,218	67.2	115.8
512	1,024	.....	.....	.....	2,270	73.5	114.0
513	1,026	.....	.....	.....	2,426	66.5	113,8
514	1,028	.....	.....	.....	2,174	67.0	110.6

Mean widths, mean depths, and means of maximum depths of 2-mile sections of main river from Cairo, Illinois, to Head of Passes—Continued.

No. of section.	Distance from Cairo.	Medium stage.			Bank-full stage.		
		Mean width.	Mean depth.	Mean of maximum depth.	Mean width.	Mean depth.	Mean of maximum depth.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
515	1,030	.....	.....	.....	2,490	60.9	102.1
516	1,032	.....	.....	.....	2,531	60.5	102.1
517	1,034	.....	.....	.....	2,744	63.9	115.1
518	1,036	.....	.....	.....	2,349	76.4	115.8
519	1,038	.....	.....	.....	2,187	94.7	157.2
520	1,040	.....	.....	.....	2,637	70.6	113.7
521	1,042	.....	.....	.....	2,537	61.0	90.2
522	1,044	.....	.....	.....	2,526	61.8	82.6
523	1,046	.....	.....	.....	2,638	61.7	83.5
524	1,048	.....	.....	.....	2,771	58.9	100.6
525	1,050	.....	.....	.....	2,634	57.0	94.3
526	1,052	.....	.....	.....	3,252	52.6	85.8
527	1,054	.....	.....	.....	3,967	41.3	63.6
528	1,056	.....	.....	.....	4,852	33.9	48.5
529	1,058	.....	.....	.....	7,177	27.0	38.3

REPORT OF CAPTAIN CHARLES F. POWELL, CORPS OF ENGINEERS, UPON RELATION BETWEEN MEAN BANK HEIGHT AND MEAN HIGH WATER.

ST. LOUIS, MO., *January* 10, 1890.

GENERAL: I have to submit the following report of the results of an investigation of the relation between mean heights of the Mississippi River banks at or near certain stations below Cairo, and mean high water as found from the yearly high-water readings since 1872 inclusive, as requested in your letter of September 25.

Ten gauge stations, Cairo, Memphis, Helena, mouth of White River, Lake Providence, Vicksburg, Natchez, Red River Landing, Baton Rouge, and Carrollton, were available. Carrollton was not used at first, since the bank elevations at that place were not then known. One year's high-water readings at Red River Landing are missing; interpolating from the adjacent stations, Natchez or Baton Rouge, the eighteen-year mean at the landing is 41.9 feet. This was used. The seventeen-year mean is 42.1 feet. Three years' high-water readings are missing at mouth of White River; one year was supplied by an observed high-water mark; the mean, 45.3 feet, of the sixteen years was used. The eighteen-year mean with interpolated values from Helena the two missing years is 44.7 feet, and from Lake Providence, 45.3 feet. There is a closer correspondence or relation between the Helena and White River high-water readings than between those of White River and Lake Providence, and, considering distances between gauges and probable influence of tributaries, I think now that it would have been safer to interpolate for White River from Helena. Such method would reduce the local difference of elevation between mean bank and mean high water from that given in the table below.

To increase the number of observations and to divide the distances between the stations named, I thought it desirable to also include in the investigation those gauge stations, established in 1880, where the mean high water since 1872 could be deduced within a fairly close approximation to the actual value. For determining this the differences between corresponding observed yearly high waters at each of the 1880 stations and the adjacent 1872 stations were noted, and the rule adopted to select those 1880 stations where the range of differences was less than 2.5 feet, a small range being evidence of a close relation between the corresponding high waters at the respective stations. The stations thus selected and the ranges of differences are, Fulton, 2.46 feet; Arkansas City, 1.3 feet; Greenville, 1.57 feet; St. Joseph, 2.26 feet, and Port Hickey, 1.20 feet. The adopted mean for each 1880 station was then derived from the proportion comprised by the means of the corresponding high waters at the station and at its standard 1872 station, and the eighteen-year means for the same stations.

With the mean high-water readings thus adopted, the bank elevations from the topographic surveys, and observed local high-water slopes, assistant engineer C. W. Clark has obtained the differences between mean high-water and mean bank for two or more reaches, generally 3 miles long, at or in the immediate vicinity of the sta-

tions. He has also noted and discussed for each station the physical conditions which in our judgment might influence the river's effort to build its banks. Mr. Clark's report with tabulation is attached.

Subsequently some bank sections at and near Carrollton were obtained, from which it is found that the right bank is 0.2 foot higher and the left bank 0.9 foot lower than mean high water. The bank elevations here are not sufficient in number nor distribution to give a comparison with mean high water as satisfactory as at the other stations. A deterioration of the immediate bank from wear and steamer wash might be expected at a large harbor and in a greater degree on the occupied side.

To divide the otherwise long distance from Baton Rouge to Carrollton for our comparison of mean high water with mean bank, and to try another method of obtaining the comparison, a plot was made of the bank elevations from Baton Rouge to Donaldsonville (the limit towards Carrollton of the topographic survey) and of a mean high-water grade line over the same reach. This line was obtained by adjusting from observed high-water slopes at intermediate stations the average grade, plotted by connecting the mean high-water readings at Baton Rouge and Carrollton, the including stations. The adjustment having been carefully made and for a part at an end of the reach, and of less than one-half the distance of the whole, any resulting error of the mean high-water grade is thought to be quite inconsiderable. From this plot it is found that the right bank, Baton Rouge to Donaldsonville, has 36 miles above and 16 miles below mean high water, averaging 0.53 foot above; and the left bank 36.5 miles above and 15.5 miles below, averaging 0.50 foot above mean high water.

Summarizing the measurements, it may be stated that at the stations and on the reach examined the bank from Cairo to Memphis, 230 miles, is from 0.5 foot to 2.8 feet above mean high water; from Memphis to Chotard Landing, 240 miles, the bank is below from 0.4 foot to 1.4 feet; from Chotard Landing to Donaldsonville, 314 miles, the bank is above from 0.2 foot to 3.8 feet, and at Carrollton is below, about 0.4 foot. Also that, on the whole, the mean bank, Cairo to Carrollton, is somewhat above adopted mean high water.

The adopted means have been obtained from the systematic and continuous gauge readings; they may not be the true ones, although eighteen years' reliable observations ought to give good results. If the means differ from true ones, they would most probably do so by respective corrections about proportional to the ranges, exhibited in the table below, between the adopted mean high and highest water on the gauges:

Station or reach.	Interval or length.	Mean bank as to mean high water.	Length of reach.	Well defined cut-offs.	Doubtful cut-offs.
	Miles.	*Feet.*	*Miles.*		
Cairo	.....	0.5 above	.....	.....	.....
Fulton	175	2.8 above	.....	.....	.....
Memphis	55	.....	230	2	9
Helena	76	1.4 below	.....	.....	.....
White River	87	0.9 below	.....	.....	.....
Arkansas City	40	1.1 below	.....	.....	.....
Greenville	45	0.4 below	.....	.....	.....
Lake Providence	74	0.5 below	.....	.....	.....
Chotard Landing	28	.....	240	17	17
Vicksburg	29	0.6 above	.....	.....	.....
St. Joseph	48	0.8 above	.....	.....	.....
Natchez	52	3.8 above	.....	.....	.....
Red River Landing	65	1.4 above	.....	.....	.....
Port Hickey	45	2.6 above	.....	.....	.....
Baton Rouge	23	0.2 above	.....	.....	.....
Baton Rouge to Donaldsonville	52	0.5 above	314	13	2
Carrollton	72	0.4 below	72	.....	.....

Station or reach.	On gauge, 1872–1889.					
	Mean high water.	Lowest water.*	Highest water.	Range.		Average yearly duration high above mean high.
				Highest and lowest.	Highest and mean high.	
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Days.*
Cairo	44.34	—1.00	52.17	53.17	7.83	14
Fulton	33.04	+1.60	36.69	35.09	3.65	.....
Memphis	32.52	—0.95	35.30	36 25	2.78	21
Helena	42.81	—0.20	48.10	48.30	5.29	18
White River	†45.33	.....	48.40	48.40	3.07	17
Arkansas City	44.09	+0.30	47.00	46.70	2.91	.....
Greenville	39.48	+1.85	41.68	39.83	2.20	.....
Lake Providence	36.55	—3.85	38.40	42.25	1.85	24
Chotard Landing	.....	.....	.....	.....	.....	.....
Vicksburg	42.90	—3.92	49.00	52.92	6.10	25
St. Joseph	39.77	.....	44 90	.....	5.13	.....
Natchez	42.20	.....	47.75	47.75	5.55	29
Red River Landing	41.92	.....	48.50	48.50	6.58	25
Port Hickey	42.19	.....	47.90	.....	5.71	.....
Baton Rouge	31.73	+1.15	36.20	35.05	4.47	26
Baton Rouge to Donaldsonville	.....	.....	.....	.....	.....	.....
Carrollton	13.28	—1.60	15.70	17.30	2.42	26

* From 1880–1889 only, for Fulton, Arkansas City, and Greenville.
† Interpolating for two missing years from Helena the eighteen-year mean would be 44.7.

It may be noticed from Mr. Clark's discussion that the more pronounced physical characteristic of the river or its banks, subject to control and therein discussed, and which presents a concurrence with bank height, is a degree of permanence of bank; it is justly concluded from the observations that convex banks are generally high; that the indications are that concave banks are low; that a caving bank does not build high, while freedom from caving insures high bank, and that for stable convex or straight bank, mean bank is almost always higher than mean high water. The concurrences might be expected as logically resulting from the well known processes of bank-building by river deposits.

The conclusion of a relation or dependence between bank stability and high bank is verified from a consideration, exhibited in the table above, of bank elevations in reference to reaches of cut-offs, and in view of the fact established by numerous observations that cut-offs induce bank-caving above and below. To serve as an extension of the table on this point, it might be explained that below Carrollton no evidences of cut-offs are shown on our maps, and a reference made to the statement in the report of the committee on levees, appendix F of the Commission's report, 1881, that below the forts the banks are approximately at the level of flood plane, and also the fact that the lower part of the river has generally stable and straight banks.

The conclusion seems warranted that banks somewhat higher than otherwise will result, incidentally, from bank protection and prevention of cut-offs, two objects to be attained in the Commission plans for river-channel improvement.

The observations further appear to show where the direction of overflow is normal to the river that the banks are less high than where the overflow is oblique, nearly parallel, or parallel to the river, the latter class not including the case of points over which water escapes and falls into the river on their lower sides. Other things being equal, especially in the matter of obstructions to the flow, these results may be explained by the greater slope of the ground away from the river than along it, sometimes as much as twenty times greater; and by the fact that when the velocity of overflow is slackened by the filling of reservoirs the induced deposits occur at or near the bank for parallel and oblique overflows, and more remote from the bank for normal overflows.

The tabluated observations do not show that the natural bank height is influenced by levees; it should be noticed, however, that in these observations the banks examined as to levees are above Baton Rouge, and are where the levees had been very generally disconnected and were back from the immediate bank of the river; also that the number of observations as to levees is not large.

Below Baton Rouge the levees have been generally continuous, were much older, and are close to the river. A detailed examination was made as to the levees on the

right bank from Port Hickey, and on the left bank from Baton Rouge, to Donaldsonville, and it was found that the natural ground outside (river side) of the levees averaged about 2.1 feet above the ground inside (land side of the levees, at a few places the outside ground being within a foot of the levee top. About 0.7 feet of the difference is accounted for by the natural slope of the ground back from the river as found from 107 half-mile bank sections below Hermitage Landing, and a consideration of the average distance of the observed elevations on the two sides of the levee. Some exaggeration of the difference may further have come from outside elevations having been taken on unidentified old levee and possibly from inside elevations at borrow-pits. After liberally allowing for these conditions the available data show that on the lower part of the river the levees have not stopped the bank building process. To find whether they have aided or retarded it a test was made as to permanence of levee from a comparison of locations by the Delta survey and the present survey on the common part and where the connections were not doubtful, viz: on the right bank from Fausse River, and on the left bank from Baton Rouge, to Donaldsonville. Twenty-three reaches are available for comparison. Dividing them into three classes, (1) Where the levees of 1851 were intact or nearly intact in 1883, aggregating 58 miles; (2) Where parts of the levees of 1851 remained but with considerable change of the other portions, 30 miles; and (3) Where the levees of 1851 had entirely or almost entirely disappeared, aggregating 33 miles, it was found that the difference of average heights of ground outside and inside of levees were respectively 1.4, 2.0, and 2.3 feet. The available reaches were further divided into classes, according to the plan of the levee and to its location, as in bend or on straight bank, etc., from which the following was obtained:

Average difference of elevations outside and inside of levee.	Conditions.
2.2 feet	Levee line very angular; many spurs towards the shore.
1.9 feet	Levee line less broken; fewer spurs than above.
1.3 feet	Levee smooth; very few spurs on sharp turns.
2.1 feet	Levee in bends.
1.9 feet	Levee along straight banks.
1.5 feet	Levee on points included by straight reaches.
0.8 feet	Levee line points.

It thus appears that either permanent levees on the lower part of the river, where close to the shore, retard the bank building, or, what seems more decided, that the broken line of levee with outward spurs or wings favors the process.

The effect on bank building of wooded as against cultivated ground is discussed by Mr. Clark, and also that of certain characteristics of the river not subject to control or change; of the latter class the effect of tributaries appears to be the most pronounced.

Very respectfully, your obedient servant,

CHAS. F. POWELL,
Captain, Corps of Engineers.

Gen. C. B. COMSTOCK, U. S. A.,
President Mississippi River Commission.

REPORT OF MR. C. W. CLARK, ASSISTANT ENGINEER.

OCTOBER 26, 1889.

CAPTAIN: I have the honor to make the following report upon relative heights of mean bank and mean high water of the Mississippi River, Cairo, Ill., to Baton Rouge, La. Fourteen stations were used for the comparison.

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The number of reaches examined vary from two to five at each station; a total number of forty-one reaches was used.

In some cases the reach considered lay entirely above or below the gauge; in such cases a slope correction for the distance from the center of the reach to the gauge was applied, the slope per mile being determined from the high-water slopes for several years, as published in the Mississippi River Commission Reports for the respective stations considered. * * * The majority of the reaches considered were 3 miles each in length. Where levees or railroad embankments lay near the shore, elevations

each side of the same were used in getting the mean. At Cairo and Memphis published charts were used (principally) for getting the bank heights; for the other twelve stations the original field plats were used. The average number of elevations used for getting bank height for a single reach was about eighteen or twenty, but in extreme cases seven to thirty were used. It is believed that the mean bank was in each case quite accurately determined in this way.

Tabulated sheets numbered 1 to 11 give the "Mean high waters," "Extreme high waters," "Mean bank elevation," "Differences," by subtracting mean bank from mean high-water elevations, and descriptions of reaches, their location, etc., so that only a discussion of the results need be taken up here. In the following M. B. will be used for mean bank, M. H. W. for mean high water, and E. H. W. for extreme high water.

Of the forty-one reaches we find that twenty-one have M. B. higher than M. H. W., eighteen have M. B. lower than M. H. W., and two have M. B. same as M. H. W. Out of the fourteen stations eleven have one or more reaches where M. B. is greater than M. H. W., and nine have one or more reaches where M. B. is less than M. H. W. Taking the mean of the M. B.'s at each station, we find that at eight stations M. B. is higher than M. H. W., and at six stations M. B. is lower than M. H. W. The latter six are in regular order taken from Memphis to Lake Providence, viz, Memphis, Helena, Mouth of White River, Arkansas City, Greenville, and Lake Providence.

The following conditions regarding the reaches will be considered to determine, if possible, their effect on bank building: (1) Bank leveed or unleveed; (2) bank cultivated or wooded; (3) bank convex, concave, or straight; (4) bank caving rapidly, slightly, or not at all; (5) flood water flowing over bank out of river, over bank into river, or over bank parallel, or nearly parallel, to shore; (6) Entrance of tributary into the river; (7) bluffs near bank; (8) range of H. W. elevations for the series of years considered at each station, and (9) Length of time that water remains above mean high water.

1. Where levees lie near the shore we find at seven reaches (representing five stations) M. B. is higher than M. H. W., nine reaches (representing six stations) M. B. is lower than M. H. W., and two reaches (representing two stations) M. B. is the same as M. H. W. On reaches where there are no levees back we find at nine reaches (representing five stations) M. B. is higher than M. H. W., and eight reaches (representing five stations) M. B. is lower than M. H. W. Of cases where levee lies back of a part of the reach we find five reaches (representing five stations) where M. B. is higher than M. H. W., and one reach M. B. is lower than M. H. W. It would seem from the above that the fact of the bank being leveed or not has little effect on the bank building at the reaches considered, elevations each side of the levee being taken to get the mean. It is true that the ground outside (river side) the levee is usually a little higher than inside (land side), about 0.45 feet, as shown by an examination of about 500 miles of river above Baton Rouge—levee averaging about one-fourth of a mile back—(see Mississippi River Commission Reports 1882 and 1883); but the high ground is usually less than one-fourth of a mile back, and the natural slope (for probably one-eighth of a mile) of the ground back from high ground would have to be considered. Now as bank slopes from 4 to 10 feet per mile away from the river (Mississippi River Commission Report 1882) we should expect to find a difference of that amount or more due to slope alone. From the last consideration it would seem more nearly correct to take only elevations outside the levee where it lies more than about one-eighth of a mile back. In the cases actually considered, however, the introduction of the elevations back of the levee in no case had an effect of changing the mean more than 0.1 foot or 0.2 foot, and in most cases probably the mean was not affected by an appreciable amount.

2. Of reaches where the banks were cultivated, we find eight reaches (representing six stations) where M. B. is higher than M. H. W., and seven reaches (representing four stations) where M. B. is lower than M. H. W. Where banks are wooded we have four reaches where M. B. is higher than M. H. W., and two reaches M. B. lower than M. H. W. Where banks are partly cultivated and partly wooded we have nine reaches where M. B. is higher and nine reaches where it is lower than M. H. W. As far as these results go there is but little to indicate that there is any difference in the bank-building process between cultivated and wooded banks; but as in general the higher lands have originally been selected for cultivation it is perhaps not a correct test to make a comparison in this way. It seems reasonable to expect that wooded banks by arresting the flow of water would cause a greater deposit, but it is possible that this might be offset by the greater volume of water that would flow over the unobstructed (cultivated) bank.

3. Where bank is convex we find ten reaches (representing seven stations) where M. B. is higher than M. H. W., and four reaches (representing four stations) where M. B. is lower than M. H. W. Where bank is concave we have three reaches (three stations) where M. B. is higher than M. H. W., and five reaches (five stations) where M. B. is lower than M. H. W., and one reach where M. B. is same as M. H. W. Where

bank is partly convex and partly concave we have one reach M. B. is higher and two reaches lower than M. H. W. Where banks are straight we have seven reaches (representing four stations) where M. B. is higher than M. H. W., seven reaches (representing four stations) M. B. is lower than M. H. W., and one reach M. B. is same height as M. H. W. We notice from the above that convex banks are generally high, while the indications are that concave banks are low, although the data here is hardly sufficient by itself to make this conclusive; we would expect, however, that the caving banks would be low, and they are generally the concave banks; where banks are straight, we see there is an equal division between the high and low banks.

4. Where banks were caving rapidly (at time the survey was made) we have two reaches where M. B. was higher, two reaches lower, and one reach same as M. H. W. Where bank was caving, but not rapidly, we have seven reaches (representing five stations) M. B. higher, and twelve reaches (representing eight stations) lower than M. H. W., and one reach M. B. same height as M. H. W. Where banks were not caving (at time of surveys), we find twelve reaches (representing ten stations) where M. B. is higher than M. H. W., and four reaches (four stations) where M. B. is lower than M. H. W. Although the caving at time of survey is not a sure indication of what the bank has been doing the period of eighteen years under discussion, yet these observations would go to show that the bank does not build up to its normal height while subject to caving, while freedom from caving insures high bank building, other conditions being normal.

If we examine this condition (4) in connection with the previous one (3) we find that for the convex bank where M. B. is higher than M .H. W., seven out of the ten cases are where bank is not caving, two where it is caving slightly, and one where it is caving rapidly; where M. B. is lower than M. H. W. we find one case bank not caving, the other three cases bank caving. For concave banks where M. B. is higher than M. H. W., one case not caving, two cases caving slightly; where M. B. is lower or same height as M. H. W., two cases not caving, four cases caving, (three cases caving rapidly). For straight bank where M. B. is higher than M. H. W., four cases not caving, three cases caving; where M. B. is lower than M. H. W., only one case is where bank is not caving and seven cases where it is caving. The above shows that where bank is convex or straight and not caving M. B. is almost always higher than M. H. W.; only two cases out of thirteen to the contrary.

5. In most cases there is no data except position of contours to determine the direction of flow of flood waters over the banks and it is doubtless the case that for a number of the reaches here considered the water flows over the banks to low grounds but is put down here as flowing parallel to the shore; because the direction of flow is at such an acute angle with the shore that the contours are not a precise enough guide for determining the actual conditions; the effect on bank building would be but little different, probably, as it is pretty safe to assume that water flowing from the basins into the river will seldom, if ever, come under the above conditions of flow; so that we may assume that waters flowing along the bank and nearly parallel with it have but recently left the river. We find from the tabulations that where water flows back to low ground over the banks, at three reaches (representing three stations) the M. B. is higher than M. H. W. and eight reaches (representing five stations) M. B. is lower than M. H. W. Where water is flowing over the banks into the river we find one reach M. B. is higher and two reaches lower than M. H. W. Where the water flows over the banks and apparently parallel to them we find seventeen reaches (representing nine stations) where M. B. is higher than M. H. W., eight reaches (representing seven stations) where M. B. is lower than M. H. W. and two reaches where M. B. is the same as M. H. W. These results show that flood waters flowing over bank and nearly parallel with it are the best conditions for high bank building.

6. In cases of tributaries emptying into the river we find that the bank below on the tributary side is lower than the bank on the opposite side of the river. At Cairo (considering the Ohio River a tributary) it is 1 foot lower; at Helena it is 3.3 feet lower; at mouth of White River it is 0.5 foot lower, and at Red River Landing it is 3.5 feet lower. The banks below mouths of Arkansas and Yazoo rivers were also examined and the same condition found to exist; at Arkansas River the bank on tributary side is 0.5 foot lower than the opposite, and at Yazoo River it is 1.5 feet lower. It seems probable that the cause for this is that the water of the tributaries is less heavily laden with silt, etc., and, to a certain extent, dilutes the water flowing along the bank below the mouth from which it empties, and perhaps in some cases materially deflecting the heavily laden waters of the main river to the opposite bank.

7. Where bluffs are on the same side and in the vicinity of the reach we find seven reaches (representing seven stations) where M. B. is higher than M. H. W., and four reaches (representing three stations) where M. B. is lower than M. H. W. Of the first seven cases six were where the reach lay below or mostly below where bluffs make back from near the shore, and in the remaining case a point of bluffs

comes near shore about the center of the reach. Of the four reaches where M. B. is lower than M. H. W., only one lies below where bluffs make back from the river, and in that case the reach is 1.8 feet higher than one directly above lying in front of the bluffs; one reach in this class lies entirely above the bluffs, the remaining two lie in front of the bluffs. Thus we see that where a line of bluffs makes back from the river it aids in bank building on reaches immediately below and on the same side of the river. This is probably due to the flood water being confined by the bluffs above, on that side, and spreading out over the flats below the bluffs with decreased velocity.

8. Taking the differences between M. H. W. and extreme H. W. for the period of eighteen years at the fourteen stations, we find the mean to be 4.5 feet. Now, where the average M. B. is higher than M. H. W., we have six cases where the above-mentioned difference at a station is greater than this mean difference, and only two such cases where it is less; on the other hand, where the average M. B. is lower than M. H. W. we find five cases where this difference is less than this mean difference, and but one case where it is greater. This shows that a great range in the elevations of high waters at a station is favorable to high-bank building. If we consider the differences between M. H. W. for this period of eighteen years and extreme H. W.'s known at the several stations, the only effect on the above is to somewhat increase the mean difference, but not sufficiently to change any of the above conditions.

9. *Length of time that water remains above M. H. W.*—For this investigation a period of eighteen years was taken, and the mean number of days per year found, during which the flood waters remained above M. H. W. at each of the fourteen stations; where observations at a station did not extend over the entire period, a comparison was made for the observed years with the corresponding years for contiguous stations having the observations complete, and thus a proportion formed for determining the mean for the period of eighteen years; the results thus found are probably very close to the true result. In most cases a comparison was made with contiguous stations above and below, and the greatest difference thus found in the two results was three days, other cases differing but one day. The average period for stations where M. B. is higher than M. H. W. is twenty-four and a half days, and where M. B. is lower than M. H. W. the average is twenty-one and a half days. Taking a mean of this period for all the stations, we find that where M. B. is higher than M. H. W., at two stations the number of days above M. H. W. is less than this mean, and at six stations it is greater; where M. B. is lower than M. H. W., at two stations it is above this mean and at four stations below. For the stations with extreme high and low banks we find for the period above M. H. W. at Natchez (the highest bank) twenty-nine days; at Fulton (next highest bank) eighteen days; Port Hickey (next to Fulton in high banks), thirty-four days; Red River Landing (next to Port Hickey), twenty-six days; at Helena (lowest bank), eighteen days; Arkansas City (next lowest bank), eighteen days, and mouth of White River (next to Arkansas City in low banks), twenty days. From the above we conclude that in general a long period for flood waters above M. H. W. is favorable to high-bank building.

An examination was also made of the average number of days per year in which the flood waters remained above the mean bank at each of the stations. The average period for stations where M. B. is higher than M. H. W. is fourteen and one-half days, and where M. B. is lower than M. H. W., twenty-nine days.

For stations with high banks we have in their order Natchez three days, Fulton two and one-half days, Port Hickey seventeen days, and Red River Landing eighteen days; for stations with low banks we have in order Helena thirty-two days, Arkansas City twenty-nine days, and Mouth of White River twenty-nine days. Thus we see that the present conditions are that stations with low banks are submerged much longer than those stations with high banks, although the period for flood waters above M. H. W. is generally less for the stations with low banks. We see that the condition of long period of flood is to-day favorable to stations of low banks, in comparison with those of high, while at some period in the past the reverse has been true.

Of the nine conditions considered we have found that for one and two, the effect on bank building is indifferent; for three and four in connection, a convex or straight bank not caving is favorable to high-bank building, while convex and caving the effect is indifferent; while for straight or concave banks caving, the tendency is against high banks especially if the caving is rapid; for five flood waters flowing over bank normal to it are detrimental to high-bank building, while flowing over and nearly parallel with the bank is beneficial to high-bank building; for six, we found the entrance of tributaries detrimental to bank below on tributary side while possibly beneficial to the opposite bank; for seven, we found bluffs making back from bank was beneficial to high-bank building below and on the same side of the river; for eighth case we found a wide range in elevations of high waters beneficial to high-bank building; and for ninth case a long period of flood waters above M. H. W. is favorable to high bank building. It is not possible with the data at hand to give with certainty a correct ratio to these different individual conditions in examining their combined

effect. We will assume weights, however, as follows: First, for favorable conditions, convex or straight bank, not caving (1); flood water flowing over and parallel to bank ($\frac{1}{2}$); bluffs making back from bank above reach (1); range of elevations above the mean range (1); where the number of days that the water is above M. H. W. at a station exceeds the mean for all stations by from two to five days, ($\frac{1}{2}$); where from five to ten days, (1); and where over ten days, ($1\frac{1}{2}$); second, for unfavorable conditions; concave or straight bank caving rapidly, (1); concave or straight bank caving (but not rapidly), ($\frac{1}{2}$); water flowing over and normal to bank, ($\frac{1}{2}$); entrance of tributary above, ($\frac{1}{2}$); range of elevations of high water below the mean range, (1); where the number of days that the water is above M. H. W. at a station is less than the mean for all stations by from two to five days, ($\frac{1}{2}$); where from five to ten days, (1); and where over ten days, ($1\frac{1}{2}$). Applying these weights to the conditions for each individual reach and summating them for each station we get the following table:

Station.	Sum of weights of conditions.		Average M. B. above or below M. H. W.
	Favorable.	Unfavorable.	
Cairo	$5\frac{1}{2}$	$3\frac{1}{2}$	Above 0.52 foot.
Fulton	3	2	Above 2.80 feet.
Memphis	2	4	Below 0.05 foot.
Helena	3	$4\frac{1}{2}$	Below 1.40 feet.
Mouth of White River	$\frac{1}{2}$	6	Below 0.92 foot.
Arkansas City	$1\frac{1}{2}$	3	Below 1.10 feet.
Greenville	$1\frac{1}{2}$	$2\frac{1}{2}$	Below 0.35 foot.
Lake Providence	1	1	Below 0.55 foot.
Vicksburg	6	$1\frac{1}{2}$	Above 0.62 foot.
St. Joseph	3	.....	Above 0.75 foot.
Natchez	5	$\frac{1}{2}$	Above 3.77 feet.
Red River Landing	$2\frac{1}{2}$	$1\frac{1}{2}$	Above 1.35 feet.
Port Hickey	6	.....	Above 2.60 feet.
Baton Rouge	$2\frac{1}{2}$	$1\frac{1}{2}$	Above 0.25 foot.

This table shows that in all cases where M. B. is greater than M. H. W. the percentage of favorable conditions is greater than that of unfavorable, and where M. B. is lower than M. H. W. the reverse is true, with the single exception of Lake Providence, where the percentages of favorable and unfavorable conditions are the same.

At Helena we find the extreme low bank, being 1.4 feet, lower than M. H. W.; this may be largely accounted for by the large volume of water flowing from the St. Francis Basin into the river at this station. This flood water having traveled for many miles, mostly among timbered lands, has probably lost a large percentage of the sediment taken from the river and gathered a small amount from the basin, so it is probably carrying a comparatively small percentage when it passes Helena.

At Natchez we find the maximum height of bank being 3.77 feet above M. H. W., and here we find the conditions almost entirely favorable to high-bank building.

At Vicksburg we find the conditions very favorable were it not for the flood waters from the Yazoo Basin; except for this condition we might expect to find Vicksburg with a maximum or nearly maximum height of bank.

It is quite possible that there are other conditions having good or bad effects on bank building which have not been noticed in this paper, but it is believed the principal ones have been examined, and it seems, when taken in combination, that they explain fairly well the conditions of banks that we find for the several stations.

The results finally show that the banks may build considerably above mean high water where a large percentage of the above-found favorable conditions exist, but that at many places there are enough unfavorable conditions to prevent the bank from building to a height equal to M. H. W., so it would seem that the mean bank for the river through the alluvial valley is not far from the height of M. H. W., with a probability of its being a little higher.

Very respectfully, your obedient servant,

C. W. CLARK,
Assistant Engineer.

Capt. CHAS. F. POWELL,
Corps of Engineers,
Secretary Mississippi River Commission.

Locality.	Mean elevation of banks above Memphis datum.	Differences—mean bank and mean high-water elevations.	Remarks.
Cairo:	*Feet.*	*Feet.*	
Mean high water above Memphis datum 1872–1889, inclusive, 322 feet.	*322.1	—0.1	Kentucky shore: Mean for 3-mile stretch on Kentucky shore-elevations from Comstock charts, shore slightly convex, not caving, about one-half wooded, the rest cultivated. No levee or railroad at this date, but railroad begins near the lower end of this reach and lies near shore.
Extreme high water above Memphis datum, 329.9 feet.	323.1	—1.1	Missouri shore: From center of Bird's Point to a point 3½ miles above; shore caving 50 to 75 feet per year, partly concave and partly convex; about three-fifths of the reach wooded, the rest cultivated; old levee and railroad average three-sixteenths mile back of bank on one-half of the reach; no levee, etc., back of rest of the reach; the lower end of Illinois lies between the gauge and this reach; on lower three-fourths mile of this reach H. W. flows back almost normal to bank across the point.
	†322.8	—0.8	Missouri shore: 3-mile reach, the center of which is 4½ miles below the gauge; bank straight, no caving; two-fifths cultivated, the rest wood; back of the upper three-fourths of this reach is an old bank higher than the present one; is about 323 feet high. At upper three-fourths mile of this reach, high water flows from across the point into the river.
	†322.5	—0.5	Kentucky shore: 3-mile reach, the center of which is 4½ miles below the gauge; shore straight; all woods; but little caving; bluffs one-fourth mile back of upper half of reach.
	*322.1	—0.1	Missouri shore: 3-mile reach, whose center is about 4½ miles above the gauge; straight shore; slight caving; mostly woods.
Memphis:			
Mean high water above Memphis datum 1872–1889, inclusive, 223.4 feet.	222.5	0.9	Left bank: 1⅛-mile reach, lower end about one-fourth mile above gauge; bank concave, caving rapidly on part of the reach; one-half of reach cultivated, the rest woods; contours indicate that H. W. flows across point and islands above and into the river along this reach; bluffs at and below the gauge prevent taking elevations from that part.
Extreme high water above Memphis datum, 226.1 feet.	‡223.3	0.1	Right bank: 3-mile reach opposite the gauge; bank convex, slightly caving; about three-fourths of reach woods, rest cultivated; levee average one-eighth mile back; elevations on both sides of levee used, but slight if any difference of elevations on the two sides of levee; sand-bar in front of the greater part of the reach.
	§223.5	—0.1	Left bank: 4-mile reach, the center of which is 7½ miles above Memphis gauge; bank concave, slightly caving; about two-fifths cultivated, the rest wooded, brush, vines, etc.; Ash Slough and Hatchee Lake average one-fourth mile back of the lower two-thirds of this reach; H. W. flows across to Hatchee Lake in places; a point of bluffs comes to within one-eighth mile of bank near center of this reach, but extends only a short distance near the shore.
	§224.1	—0.7	Right bank: 4-mile reach, the center of which is 7½ miles above gauge; bank convex, mostly wooded, slight if any caving; old levee average three-eighths mile back of about one-half of the reach; sand-bar in front of most of the reach.

* This result is from the reach most favorably located with reference to the gauge and may be considered more reliable than the other results.

† A slope correction applied to get these results; no H. W. slope, directly at Cairo, is known, but the mean for 1880, 1882–1884, inclusive, from Cairo to Columbus and points above Columbus, was used, this may cause a possible error in these results of 0.3 foot or 0.4 foot, but I judge the error is not more than 0.1 foot or 0.2 foot from this cause. Elevations for last result were taken from field plats of Mississippi River Commission surveys; for the other results, taken from Comstock charts.

‡ This result from reach most favorably located with reference to the gauge.

§ A slope correction applied to get these results was found by taking mean of H. W. slopes for 1880, 1882 to 1884, inclusive, and 1886–1888, inclusive.

Locality.	Mean elevation of banks above Memphis datum.	Differences—mean bank and mean high-water elevations.	Remarks.
Helena:	*Feet.*	*Feet.*	
Mean high water above Memphis datum 1872–1889, inclusive, 191.7 feet.	188.5	3.2	Right bank: 3-mile reach, gauge at center of reach; bank nearly straight, cultivated, some caving at lower part of reach; old levee and railroad near the bank for three-quarters distance over reach, from lower end tow-head in front of the reach; elevations back of levee and railroad not used because of grading of streets and of filling caused by material washed down from bluffs; lake and low ground next bluffs above Helena; water from St. Francis Basin comes to river just above Helena in flood season; mouth of St. Francis River 8¾ miles above gauge.
Extreme high water above Memphis datum, 197.0 feet.	191.8	—0.1	Left bank: 3-mile reach opposite the gauge; bank nearly straight, not caving; about one-half of reach cultivated, the rest wooded; old levee will average about seven-eighths mile back of the bank; lakes and low ground between the bank and the levee; a railroad runs directly back from the bank near the center of the reach considered; water flows over this bank and into Yazoo Basin during floods.
	*190.3	1.4	Right bank: 3-mile reach, the center of which is 2¼ miles below the gauge; bank is straight, mostly cultivated, some caving; old levee will average about one-eighth mile back; at flood stage water probably flows over banks into low ground back and into White River Basin.
	*190.7	1.0	Right bank: 4½-mile reach, the center of which is 6¼ miles above the gauge; bank concave at upper end, convex below; about one-half cultivated, the rest woods; mouth of St. Francis River is at upper end of the reach; Porter Lake and low ground back of central and lower part of the reach; sand-bar in front of the lower end of the reach; some caving; at central 2½ miles of the reach contours show that at flood stages the water flows over the bank into Porter Lake.
Mouth White River:			
Mean high water above Memphis datum 1872–1889, inclusive. †160.9 feet.	159.8	1.1	Right bank: 3-mile reach; gauge about center of reach; bank straight; lower part of reach caving somewhat; willows for 1 mile at upper end; about 1 mile cultivated and the rest wooded; no levees; month of White River about 1½ miles above the gauge.
Extreme high water above Memphis datum, 164.0 feet.	160.3	0.6	Left bank: 3-mile reach; opposite the gauge; bank convex some caving; mostly cultivated; old levee near bank for 1 mile at upper end; levee below that averages about 1 mile back; probably at flood stages the water flows over bank on 1 mile of this reach and across a point.
	‡160.4	0.5	Right bank: 4-mile reach, the center of which is 2½ miles below the gauge; bank slightly concave; caving rapidly; no levee; about two-fifths of the reach cultivated, the rest wooded; contours indicate that at flood stages the water flows diagonally over the bank back to low ground.
	‡159.4	1.5	Right bank: 3½-mile reach, the center of which is 5 miles above the gauge; bank nearly straight; mostly wooded; caving somewhat; water apparently flows over bank of lower one-half of the reach and back into White River. This reach taken to see if the White River had apparently the effect of decreasing normal height of bank immediately below its mouth.
Lake Providence:			
Mean high water above Memphis datum 1872–1889, inclusive, 113 feet.	112.4	0.6	Right bank: 3-mile reach, gauge at center of reach; bank slightly convex; caving a little; cultivated; levee near bank; elevations on each side of levee used in getting the mean.
Extreme high water above Memphis datum, 114.9 feet.	112.5	0.5	Left bank: 3-mile reach opposite the gauge; bank slightly concave; cultivated; levee near bank; elevations on each side of the levee were used in getting the mean; sand-bars in front of most of the reach.

*A slope correction applied to get this result found by taking mean of H. W. slopes for 1880, 1882–1884, inclusive, and 1886–1888, inclusive.

†No record for 1878 and 1879, so that they are not included in this mean.

‡A slope correction used in getting these results found by taking mean H. W. slope for 1880, 1882–1884, inclusive, and 1886–1888, inclusive.

Locality.	Mean elevation of banks above Memphis datum.	Differences—mean bank and mean high-water elevations.	Remarks.
Vicksburg:	*Feet.*	*Feet.*	
Mean high water above Memphis datum 1872–1889, inclusive, 95.8 feet.	96.6	—0.8	Right bank: 3-mile reach on Delta Point opposite the gauge; bank around a sharp point; rapidly caving on upper side; not caving on lower side; levee near lower main bank; a new bank built out from lower side of point covered with willows; has some elevations nearly as high as main bank; several levees run across the point; main bank cultivated.
Extreme high water above Memphis datum, 101.9 feet.	94.0	1.8	Left bank: 1½-mile reach, lying below the gauge; bluffs along bank prevent using elevations above the gauge; bank cultivated; not caving; bluffs average one-fourth back of this reach.
	*95.3	0.5	Right bank: 3-mile reach, the center of which is 4½ miles below the gauge; bank nearly straight; new levee (not all built at time survey was made) is one-fourth mile back; cultivated; some caving; contours indicate that at flood stages water flows over bank of the lower mile of this reach into low ground.
	*99.8	—4.0	Left bank: 3-mile reach, the center of which is 4½ miles below the gauge; bank nearly straight; bluffs and railroad back about 1 mile; cultivated; not caving; sand-bar in front; old levee one-fourth mile back at lower end; Big Bayou empties into river at lower end of the reach.
Natches:			
Mean high water above Memphis datum 1872–1889, inclusive, 66 feet.	70.1	—4.1	Right bank: 3 mile reach opposite the gauge; bank convex; cultivated; not caving; levee near the bank; elevations each side of the levee used in getting the mean.
Extreme high water above Memphis datum, 71.5 feet.	*68.4	—2.4	Right bank: 3-mile reach, the center of which is 3 miles below the gauge; bank slightly convex, some caving; cultivated; levee near bank, elevations each side of the levee taken in getting the mean.
	*70.8	—4.8	Left bank: 3-mile reach, the center of which is 3 miles below the gauge; bank slightly concave, slowly caving; cultivated except for about one-fourth mile at the upper end, which is woods and thick vines; no levee; bluffs run back from bank above upper end of reach, and at upper end are one-fourth mile back.
Red River Landing:			
Mean high water above Memphis datum 1872–1889, inclusive, 52.6 feet.	52.2	0.4	Right bank: 3-mile reach, the gauge being about the center of the reach; bank nearly straight; slight caving; cultivated above the gauge and woods below; levee averages about one-fourth mile back; low ground and lakes lie within 1 mile back of bank. Mouth of Red River 1½ miles above gauge.
Extreme high water above Memphis datum, 59.2 feet.	55.7	—3.1	Left bank: 3-mile reach opposite the gauge; bank convex; wooded; not caving; levee at lower end and about 1 mile back; contours indicate that above this reach the water at flood stages flows over the bank and across the point, passing this reach nearly parallel with the shore.
Baton Rouge:			
Mean high water above Memphis datum 1872–1889, inclusive, 38.7 feet.	38.7	0.0	Right bank: 3 mile reach opposite the gauge; bank nearly straight, slightly convex at lower end; some caving; cultivated; old levee near bank; elevations on each side of levee used.
Extreme high water above Memphis datum, 43.1 feet.	39.2	—0.5	Left bank: 2-mile stretch; 1½ miles of it lies below the gauge. Bank slightly concave; no caving; cultivated; old levee near bank; elevations each side of levee used; bluffs back of upper part of reach.

* A slope correction applied to get these results found by taking mean of H. W. slopes for 1880, 1882-1884, inclusive, and 1886-1888, inclusive.

Locality.	Mean elevation of banks above Memphis datum.	Differences—mean bank and mean high-water elevations.	Remarks.
Fulton:	*Feet.*	*Feet.*	
Mean high water above Memphis datum 1872–1889, inclusive, 248.5 feet.*	251.2	—2.7	Right bank: 3-mile reach opposite the gauge; bank is nearly straight; but little caving; mostly cultivated; levee near bank; high water coming across a point apparently empties into the river just above this reach; a wide gap in the levee just above the head of this reach; elevations each side of the levee used.
Extreme high water above Memphis datum, 252.11 feet.	251.4	—2.9	Left bank: 3-mile reach, the center of which is 3 miles below the gauge; bank nearly straight; about two-thirds cultivated, the rest wooded; not caving; bluffs run back from shore at the upper end of the reach; mouth of Hatchee River near lower end of the reach, and head of chute of Hatchee Island at lower end of reach; no levee.
Arkansas City:			
Mean high water above Memphis datum, 147.3 feet.†	146.6	0.7	Right bank: 3-mile reach, gauge at center of reach; bank concave on lower 2 miles of reach; upper mile convex and lies back of Island 78; railroad and levee near bank; upper 1¾ miles cultivated, rest of reach wooded; some caving on lower 1¼ miles of the reach.
Extreme high water above Memphis datum, 150.22 feet.	145.8	1.5	Left bank: 3-mile reach opposite the gauge; bank convex; about one-half the reach cultivated, the rest wooded; levee close to bank for upper 1¼ miles of the reach, and averages one-fourth mile back of lower 1¾ miles of the reach; but little if any caving; contours would indicate that over the central 1½ miles of this reach the water flows over the bank and across a point at flood stages.
Greenville:			
Mean high water above Memphis datum 1872–1889, inclusive, 134.3 feet.‡	133.6	0.7	Right bank: 3-mile reach opposite the gauge; bank partly concave, partly convex; the reach lies on the lower side of a point; all except the upper mile of the reach lies behind a tow-head; but little caving; wooded; no levee.
Extreme high water above Memphis datum, 136.55 feet.	134.3	0.0	Left bank: 3-mile reach; gauge at center of the reach; bank concave; caving rapidly; about three-eighths of the reach cultivated, the rest wooded; levee and railroad average about one-eighth mile back.
St. Joseph, La:			
Mean high water above Memphis datum 1872–1889, inclusive, 79.4 feet.§	79.3	0.1	Right bank: 3-mile reach; gauge at center of the reach; bank slightly concave; one-half cultivated, the rest wooded; but little if any caving; levee will average one-eighth mile back; upper half of reach is cultivated, but lies back of a willow bar.
Extreme high water above Memphis datum, 84.51 feet.	81.0	—1.6	Left bank: 3-mile reach opposite the gauge; bank convex; sand-bar at lower half of the reach; not caving; mostly cultivated; no levee.
Port Hickey:			
Mean high water above Memphis datum 1872–1889, inclusive, 42.7 feet.‖	43.9	—1.2	Right bank: 3 mile reach opposite the gauge; bank very convex; takes in a sharp point; caving on the upper side of the point 100 feet yearly; no caving on lower half of the reach; two-thirds cultivated, the rest wooded; levee will average less than one-eighth mile back of the bank; elevations each side of the levee taken; cypress swamp back of the reach, average a little over one-half mile back.
Extreme high water above Memphis datum, 48.45 feet.	¶45.9	—3.2	Left bank: 2-mile reach, the center of which is 3½ miles above the gauge; bank convex; upper half cultivated, rest wooded; not caving; no levee.
	¶46.1	—3.4	Left bank: 2-mile reach, the center of which is 2½ miles below the gauge; bank slightly convex; cultivated; no levee; bluffs about one-eighth mile back of upper one-half mile, then bluffs run directly back from river; lake and swamp back of the rest of the reach.

* Mean of eighteen years derived from Memphis.
† Mean of sixteen years derived from mouth of White River.
‡ Mean of eighteen years derived from Lake Providence.
§ Mean of eighteen years derived from Vicksburg.
‖ Mean of eighteen years derived from Baton Rouge. Mean of six years at Port Hickey is 45.40.
¶ A slope correction applied in getting these results found by taking mean of H. W. slopes for 1880, 1883–1884, inclusive and 1886–1888, inclusive.

Results of discharge observations, Mississippi River, Old River, and Bayou des Glaises.

Station.	Date.	Gauge. Reading.	Gauge. Rise or fall in preceding 24 hours.	Cross-section of discharge. Area. Water.	Area. Below datum.	Depth. Mean	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Method.	Remarks.
	1884.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Feet.*	*Cu. ft.*			
Hays' Landing, Miss.	Feb. 18	35.31	+0.50	159,481	.....	56.8	.....	84.0	2,810	.....	7.496	1,195,493	.....	Meter	Results of other discharge observations at this station are published as follows: Jan. 1 to Nov. 25, 1882: gauge-reading from 6.05 to 38.59 feet. Rep. M. R. C., 1883, p. 222. Floods of 1882: gauge-reading 34.14 to 38.58 feet. Rep. M. R. C., 1884, p. 81. Mar. 16, 1884: gauge reading 37.72 feet. Rep. M. R. C., 1884, p. 116.
Through Waterproof Cut-off.	May 25	†40.68	—0.08	72,700	72,700	51.9	51.9	73.0	1,401	.....	*6.455	469,300	.....	Meter.	The discharges through the old channel were observed about the same times, and computed to be 370,465 cubic feet per second in May, and 231,174 cubic feet per second in July.
	July 23	21.02	—0.33	75,199	101,484	59.1	72.5	110.0	1,273	+28,784	†4.047	304,296	.....	‖ D. F	
	1882.														
Old River, one-quarter mile above the mouth.	Jan. 9	34.61	+0.45	23,461	24,794	26.4	26.9	35.7	890	.....	2.257	76,400	VI—4	...do ..	All these gauge-readings were apparently on the Red River Landing gauge. In computing the velocities no corrections have been made for the departures of the floats from the normal to the discharge section, because these departures were small and in both directions.
	Jan. 11	35.10	+0.40	23,212	24,112	25.4	26.1	37.0	913	— 682	3.248	75,382	.....	...do ..	
	Jan. 16	36.08	+0.15	22,389	22,389	24.3	24.3	38.7	923	— 1,723	2.592	58,031	XII—4	...do ..	
Bayou des Glaises, Hamburg, La.	Apr. 4	§49.30	—0.10	5,920	.....	18.5	.....	.....	320	.....	2.233	13,220	VI—2	Meter.	Results of other discharge observations at this station are published as follows: Oct. 1884, to Mar. 1885: gauge-reading from 13.61 to 48.41 feet. Rep. M. R. C., 1887, p. 2854. According to the daily log-book and reports these observations were taken Apr. 4, but the results given above were tabulated under Apr. 5. As the field notes could not be obtained, no recomputation has been made.

* The velocity observations were taken about 100 feet above the section sounded. Water surface was 87.326 feet above the Cairo datum plane.
† In computing the velocities the average departure of the floats, 46.5 feet, was assumed for each path.
‡ St. Joseph gauge. ‖ Double float. § Barbre's Landing gauge.

EXTRACTS FROM REPORT BY MR. WILLIAM GERIG, ASSISTANT ENGINEER, CHIEF OF PARTY, UPON DISCHARGE OBSERVATIONS, MISSISSIPPI RIVER, NEAR NEW MADRID, MISSOURI, 1888–'89, AND UPON THE OFFICE COMPUTATION.

MEMPHIS, TENN., *September* 5, 1889.

* * * * * * *

The party at this station consisted of one assistant engineer, one steam engineer, one steersman, and two boatmen.

Observations were made upon two sections about 1¼ miles apart. The first was called the high-water section, and was about 5 miles below New Madrid. At the end of the section on the right bank a base-line 4,829 feet long was measured nearly at right angles to the section. On each bank a series of radial signals was set, determining lines which intersected the section at points 300 feet apart called velocity stations. Signals were also set on the section to determine the river width; the distance between these signals being 6,053 feet. Distances from the water's edge to these signals were observed each day which determined the river width. In the system of intersecting ranges, on the right bank, the pivot signal was 5,302 feet from the section and a perpendicular from it intersected the section 1,084 feet from signal "B" on the prolonged section. The other signals were placed between the pivot signal and section and on the base-line. Secondary signals were set between them to locate the soundings.

As the lower stages of the river were reached in December, several undesirable features developed in the high-water section, the presence of bars near both banks made the water too shallow to allow the launch to be used, and caused the current to be deflected toward the middle of the river so that it was no longer normal to the section; as the water continued falling the bars appeared and a pocket was formed near the left bank in which there was no current. It was decided, therefore, to change the section, and a low-water section was located about 1¼ miles above the high-water section.

The manner of locating velocity and sounding stations was similar to that of the high-water section. The points at the end of this section were designated "Z" and "X," and the distance between them was 4,141.8 feet. The pivot signal was on the left bank and at a perpendicular distance from the prolonged section-line of 1,638 feet; the intersecting point was 1,147 feet from "X," the minimum angle for locating the section being 30° 45′.

The river rose in January, and on the 19th the high-water section was occupied and used till February 13 and then the low-water section till February 22.

The instruments in use consisted of Price meter No. 10, a Morse register, a break circuit clock, electric batteries, transit, level, sounding leads, lines, etc. The meter was the well-known Price meter, which had been in use on the river for several years. * * * The meter gave no trouble except once when the gutta-percha which made the break had worn down so that the electric current was not broken. The gutta-percha was removed, as well as the other pieces which held it in position, and then the contact was made on the remaining half of the axis. * * *

Much trouble was caused by the clock, which was a very old one and was frequently out of repair, at which times a watch was used, the time of beginning being marked on the ribbon with a pencil and also that of ending. * * *

The meter circuit was made through a steel sash-cord on which the meter was sussuspended, and through an insulated copper wire which was paid out with the sash-cord. A 15-pound sounding lead and a ⅜-inch cotton line were used throughout the season.

Drifting soundings were taken during the highest water, but generally soundings were taken without drifting, since the maximum depth was about 30 feet.

The meter was suspended from a boom 12 feet long at the stern of the launch, the boom projecting over the side and making an angle of about 60° down-stream with the axis of the launch. A steel sash-cord $\frac{3}{16}$-inch diameter passed around a reel in stern of launch, through a small pulley in the end of boom, thence to an iron rod 1 inch in diameter and 2 feet long. To this rod the meter was attached, and also a lead weight of about 50 pounds. Attached to the top of the rod was a fine steel piano wire, which passed through a pulley in the end of a 20-foot boom in the bow of the launch and thence to a reel. By paying out proper lengths of standing and guy lines the meter could be immersed to any desired depth. * * *

The coefficients to be used in reducing the registrations of the meter to velocity in feet per second were determined by causing the meter to move through still water over a known distance at various velocities, the time and number of registrations being noted. A float was anchored in still water, upon which a beam was revolved, at the end of which the meter was attached. The beam was of such a length that in making one revolution the meter traversed 100 feet. The meter circuit was made from the battery to the stand on which the arm was revolved, thence to the meter,

thence back by a copper wire through the register to the other pole of the battery. The clock circuit was so arranged that when the revolving arm arrived at a certain point the circuit was made and the time registered until the arm had made a revolution, when the circuit was broken and the time ceased to be recorded. This was done by a small brass arm extending up so that the revolving arm could touch it and move it till it touched another piece of brass or nickel and thus made the connection. By this method time of beginning and ending could easily be measured to one-twentieth of a second if the connection was made during the half second when the circuit was made; otherwise it could only be measured to the nearest half second. The revolutions of the meter could be measured equally as accurately. * * *

The rating observations were reduced by the method of least squares. The following are the results of the rating of the meter which were adopted for use:

Date.	No. of observations.	a	b	Mean error of observations.
Nov. 23, 1888	22	3.860	+0.215	±0.018
Apr. 17, 1889	38	3.920	+0.100	±0.020

A number of ratings were made but rejected on account of large errors which were due to the swivel not turning on its axis in changing the direction of the revolution of the arm, and thereby causing the revolutions of the meter to be retarded, and also that the brass connections upon which the arm revolved were nearly worn out, so that false registrations were made; on April 17 all these errors were eliminated and the results are very accurate.

The formulæ used in reducing were, till December 31, 1888,

$$y = 3.86\,x + 0.22, \text{ and afterwards } y = 3.92\,x + 0.10.$$

The lead line was tested every morning before using and corrected by retagging if in error. It was also tested at close of work and errors, if any, compensated by correction of soundings.

The number of seconds that the meter continued to spin was noted before and after each day's work, and the mean recorded. * * *

In the final reduction the widths were calculated and the soundings plotted on cross-section sheets, as were also the velocities. The velocities were reduced by the formulæ adopted and recorded in the note-books. The total area was divided into partial areas of 500 feet width; these partial areas were calculated by counting the squares and were multiplied by the mean velocities of the partial areas which were taken from the cross-section sheets. The product was the partial discharge, and the sum of the partial discharges gave the total discharge, and this divided by the total area gave the mean velocity. The counting of the registrations was done in the field and checked after each day's work.

The measurements for velocity were taken at six-tenths depth. The length of the observations varied from 150 seconds to 300 seconds, though generally the duration was 150 esconds. The computation of velocities from the given times and registrations was performed by means of the tables prepared for the purpose. The results of computation were copied in a tabular form accompanying this report and also into the note-books.

The gauge-readings correspond to the mean time of observation. The gauge was read at the time of beginning and ending of each day's work, which was about 8 a. m. and 4 p. m. The rise or fall in twenty-four hours is the difference in the mean gauge-reading for that day and the preceding one.

The computation of datum areas has been made in the following manner: For the high-water section the datum was assumed to correspond to the gauge-reading of 25.6 feet. The datum width was taken as 5,967 feet, that being the measured width and gauge-reading on February 27, 1889. The slope of the banks down to 20 feet on gauge was uniform, also from 20 feet to 10 feet and below 10 feet, and the datum areas have been computed by the formala:

$$\text{Datum area} = (25.6 - h)\,\frac{5967 + w}{2} + \text{water area},$$

where h = gauge and w = width.

NOTE.—For a full description of the meter and outfit and the methods of computation, see Annual Report Chief of Engineers, 1887, pages 2821–2823. (Secretary Mississippi River Commission.)

The formula between 20 feet and 10 feet on gauge becomes:

$$\text{Datum area} = (25.6 - 20)\frac{5967 + 5930}{2} + (20 - h)\frac{5930 + w}{2} + \text{water area}$$

$$= 33312 + (20 - h)\frac{5930 + w}{2} + \text{water area},$$

in which 5,930 feet is width at 20-foot stage.

For stages below 10 feet the formula is:

$$\text{Datum area} = 33312 + (20 - 10)\frac{5930 + 5820}{2} + (10 - h)\frac{5820 + w}{2} + \text{water area}$$

$$= 9206.2 + (10 - h)\frac{5820 + w}{2} + \text{water area}.$$

The low-water section datum was assumed as the surface of the water on January 18, the gauge-reading being 21 62. The width on that day was 4,023 feet, which was taken as the datum width. The slope of the banks change at 20 feet, 15 feet, and 10 feet stages, and the widths at these stages are 4,009 feet, 3,965 feet, and 3,911 feet. The formula used is:

$$\text{Datum area} = (21.62 - h)\frac{4023 + w}{2} + \text{water area}.$$

Between stages 15 feet and 20 feet the formula becomes:

$$\text{Datum area} = (21.62 - 20)\frac{4023 + 4009}{2} + 20 - h)\frac{4009 + w}{2} + \text{water area}.$$

$$= 6506 + (20 - h) + \frac{4009 + w}{2} + \text{water area}.$$

Between 15 feet and 10 feet:

$$\text{Datum area} = 6506 + (20 - 15)\frac{4009 + 3965}{2} + (15 - h)\frac{3965 + w}{2} + \text{water area}$$

$$= 26441 + (15 - h)\frac{3965 + w}{2} + \text{water area}.$$

Below 10 feet:

$$\text{Datum area} = 26441 + (15 - 10)\frac{3965 + 3911}{2} + (10 - h)\frac{3911 + w}{2} + \text{water area}$$

$$= 46131 + (10 - h)\frac{3911 + w}{2} + \text{water area}.$$

Mean depth has been obtained by dividing the water area by the width, and mean datum depth has been obtained by dividing the datum area by the datum width. Maximum depth was taken directly from the notes. Scour or fill has been obtained by taking the difference of the datum areas; scour is indicated by the positive sign.

The direction of the wind is indicated by dividing the horizon into twelve parts and numbering the parts the same as the hours on a clock dial, XII being up-stream and indicating a down-stream wind.

A plot has been made with the mean velocities and discharges of both sections as ordinates and the gauge heights as abscissas. The scales for each system are shown on the plot. * * *

Herewith also find a tracing showing the location of the sections.

The entire work has been checked in various ways and great care has been taken to eliminate all errors of computation.

* * * * * * *

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*Results of discharge observations, Mississippi River, New Madrid, Missouri, 1888–1889.**

METHOD.—Meter at six-tenths depth from the surface.

Date.	Gauge.		Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
	Reading.	Rise or fall in the preceding 24 hours.†	Area.		Depth.			Width.				
			Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1888.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	
Nov. 28	18.50						30.0	5,915				1—Slight.
29	17.30	—1.20					28.0	5,913				XII—Slight.
30	16.30	—1.00					31.0	5,908				XII—Strong.
Dec. 1	15.25	—1.05	125,650	187,068	21.3	31.3	30.0	5,905		3.460	434,751	X—Slight.
3	12.80	—2.45	112,320	188,147	19.1	31.5	29.6	5,880	+1,079	3.383	379,995	X—Slight.
4	12.05	—0.75	103,004	183,237	17.5	30.7	29.0	5,873	—4,910	3.255	335,220	IX—Slight.
5	11.30	—0.75	100,195	184,837	17.1	31.0	28.0	5,870	+1,600	3.219	322,582	XI—Strong.
6	10.35	—0.95	97,415	187,642	16.6	31.4	26.0	5,865	+2,805	3.140	305,854	VIII—Mild.
7	9.70	—0.65	94,500	188,330	16.4	31.6	25.5	5,772	+ 688	3.234	305,577	V—Strong.
8	9.20	—0.50	89,840	186,493	15.8	31.3	25.0	5,657	—1,837	3.164	284,209	VI—Slight.
10	8.62	—0.57	84,200	183,879	16.6	30.8	23.0	5,301	—2,614	3.076	247,362	II—Mild.
11	8.32	—0.30	80,146	181,491	16.0	30.4	22.5	5,275	—2,388	3.082	235,282	XII—Mild.
12	8.04	—0.29	75,867	178,907	15.2	30.1	22.5	5,267	—2,584	3.129	223,009	XII—Mild.
13	7.74	—0.30	73,910	128,844	19.1	32.0	26.0	3,868	(‡)	2.951	218,082	XII—Mild.
14	7.44	—0.30	73,190	129,285	19.2	32.1	25.0	3,866	+ 441	2.983	218,359	V—Strong.
15	7.20	—0.24	73,125	130,145	19.0	32.3	25.0	3,866	+ 860	3.030	221,208	V—Very strong.
17	6.90	—0.30	72,820	131,000	18.8	32.6	25.5	3,863	+ 855	2.950	214,623	XI—Strong.
18	6.90	0.00	75,258	133,438	19.5	33.2	26.5	3,862	+2,438	2.890	217,282	X—Slight.
19	7.00	+0.10	74,226	132,021	19.2	32.8	26.0	3,864	—1,417	2.950	218,922	XII—Slight.
20	7.19	+0.19	75,760	132,825	19.6	33.0	25.5	3,864	+ 804	2.975	225,394	VII—Strong.
21	7.47	+0.29	75,935	131,883	19.7	32.7	26.0	3,865	— 942	3.020	229,446	XI—Mild.
22	8.15	+0.67	78,545	131,880	20.3	32.7	26.7	3,878	— 3	3.040	238,743	VIII—Mild.
24	8.90	+0.75	82,015	132,436	21.1	32.9	27.5	3,890	+ 556	3.177	260,486	VI—Mild.
25	9.13	+0.23	85,090	134,617	21.8	33.5	27.5	3,895	+2,181	3.200	271,930	Calm.
26	9.26	+0.13										VI—Very strong.
27	9.62	+0.26	85,295	132,907	21.8	33.0	28.0	3,908	—1,710	3.221	274,733	X—Slight.
28	10.23	+0.61	87,705	132,935	22.4	33.0	28.3	3,913	+ 28	3.290	288,182	Calm.
29	10.85	+0.62	89,895	132,691	22.9	33.0	30.0	3,917	— 244	3.360	301,806	Calm.
31	12.08	+1.23	95,305	133,283	24.2	33.1	31.0	3,935	+ 592	3.418	325,708	XII—Mild.

* From reduction at office of first district engineer.
† Where a day is omitted the rise or fall given on the following day is for 48 hours.
‡ Low-water section occupied from December 13 to January 18, and from February 14 to 21, inclusive.

Results of discharge observations, Mississippi River, New Madrid, Missouri, 1888–1889*—Continued.

METHOD.—Meter at six-tenths depth from the surface.

Date.	Gauge.		Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
	Reading.	Rise or fall in the preceding 24 hours.†	Area.		Depth.			Width.				
			Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1889.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	
Jan. 1	12.20	—0.12	97,375	134,879	24.7	33.5	32.1	3,938	+1,596	3.450	335,947	XII—Mild.
2	12.13	—0.07	97,150	134,927	24.7	33.5	32.0	3,936	+ 48	3.416	331,898	VI—Mild.
3	11.91	—0.22	96,690	135,346	24.6	33.6	31.5	3,934	+ 419	3.355	324,366	Calm.
4	11.39	—0.52	93,330	134,016	23.8	33.3	30.5	3,926	—1,330	3.316	309,476	V—Mild.
5	10.98	—0.41	92,005	134,305	23.4	33.4	29.5	3,924	+ 289	3.300	303,524	X—Slight.
7	11.17	+0.19	91,940	133,486	23.5	33.2	29.5	3,922	— 819	3.335	306,580	V—Slight.
8	11.60	+0.43	93,645	133,502	23.9	33.2	30.0	3,926	+ 16	3.380	316,141	V—Strong.
10	13.35	+1.75	99,765	132,735	25.3	33.0	32.0	3,949	— 767	3.560	354,724	VI—Slight.
11	14.95	+1.60	104,955	131,594	26.5	32.7	32.5	3,965	—1,141	3.650	383,172	XI—Slight.
12	16.95	+2.00	111,295	129,983	28.0	32.3	34.0	3,979	—1,611	3.990	444,401	V—Slight.
14	19.75	+2.80	124,350	131,858	30.7	32.7	38.0	4,007	+1,875	4.500	558,883	Calm.
15	20.28	+0.53	128,900	134,281	32.1	33.4	38.7	4,010	+2,423	4.465	575,539	V—Strong.
16	20.57	+0.29	.....	.....	.....	.....	.....	4,014	.....	.....	.....	V—Very strong.
17	20.97	+0.40	130,205	132,817	32.4	33.0	40.0	4,015	—1,464	4.580	595,303	XII—Slight.
18	21.62	+0.65	133,155	133,155	33.1	33.1	40.0	4,023	+ 338	4.540	605,016	XII—Slight.
19	22.20	+0.58	169,950	190,210	28.5	31.9	37.0	5,951	.....	3.810	645,953	XII—Mild.
21	24.10	+1.90	177,085	186,026	29.7	31.2	37.5	5,955	—4,184	3.906	691,550	XII—Mild.
22	24.53	+0.43	178,255	184,635	30.0	30.9	38.0	5,959	—1,391	3.940	702,290	VI—Strong.
23	24.15	—0.38	175,895	184,539	29.5	30.9	37.0	5,955	— 96	3.930	692,823	Calm.
24	23.35	—0.80	173,840	187,249	29.2	31.4	38.0	5,952	+2,710	3.850	670,076	XII—Slight.
25	22.20	—1.15	168,820	189,065	28.4	31.7	37.4	5,942	+1,816	3.820	644,886	Calm.
26	20.90	—1.30	159,105	187,075	27.0	31.4	35.0	5,936	—1,990	3.720	591,046	XII—Slight.
28	18.85	—2.05	146,960	187,087	24.8	31.4	33.0	5,923	+ 12	3.625	532,707	XI—Slight.
29	18.65	—0.20	145,330	186,641	24.5	31.3	32.3	5,923	— 446	3.564	518,893	XI—Slight.
30	19.10	+0.55	145,870	184,516	24.6	30.9	33.5	5,925	—2,125	3.624	528,652	XII—Strong.
31	19.93	+0.83	150,285	184,012	25.3	30.8	33.5	5,930	— 504	3.695	555,262	XI—Strong.
Feb 1	20.60	+0.67	156,050	185,805	26.3	31.1	35.0	5,935	+1,793	3.680	574,319	V—Mild.
2	21.38	+0.78	161,040	186,187	27.1	31.2	34.5	5,940	+ 382	3.713	597,961	Calm.
4	22.45	+1.07	166,745	185,509	28.0	31.1	34.8	5,946	— 678	3.830	638,696	VIII—Strong.
5	22.48	+0.03	166,735	185,327	28.0	31.1	35.3	8,951	— 182	3.837	639,729	XI—Strong.
6	22.03	—0.45	164,820	186,092	27.7	31.2	35.0	5,950	+ 765	3.830	631,680	XI—Mild.
7	21.12	—0.91	158,255	184,918	26.7	31.0	34.3	5,936	—1,174	3.873	612,887	VII—Strong.
8	19.90	—1.22	148,855	182,759	25.1	30.6	32.5	5,926	—2,159	3.590	534,501	VI—Mild.

* From reduction at office of first district engineer.

† Where a day is omitted the rise or fall given on the following day is for 48 hours.

9	18.75	—1.15	143,375	184,115	25.9	30.9	32.0	5,917	+1,356	3.547	508,610	XII—Mild.
11	16.53	—2.22	125,460	179,366	21.3	30.1	29.5	5,902	—4,749	3.463	434,511	XI—Strong.
12	15.50	—1.03	114,860	174,776	19.5	29.3	29.0	5,894	—4,593	3.398	387,841	X—Mild.
13	13.90	—1.60	110,025	179,375	18.7	30.1	28.0	5,887	+4,599	3.391	373,143	VIII—Strong.
14	12.15	—1.85	.....	.....	.....	.....	.....	3,932	*	.....	.....	Fog.
15	11.30	—0.85	.....	.....	.....	.....	.....	.....	.....	.....	.....	Fog.
16	10.53	—0.77	84,805	128,880	21.6	32.0	28.0	3,925	.....	4.481	295,178	VIII—Slight.
18	10.00	—0.53	84,370	130,501	21.5	32.4	27.7	3,914	+1,621	3.483	293,864	X—Moderate.
19	11.55	+1.55	88,825	128,880	22.7	32.0	29.0	3,926	—1,621	3.536	314,101	X—Slight.
20	14.75	+3.20	104,170	131,602	26.3	32.7	32.7	3,965	+2,722	3.981	414,847	VI—Slight.
21	18.30	+3.55	118,205	131,517	29.6	32.7	36.0	3,998	— 85	4.392	519,182	VI—Slight
22	20.75	+2.45	153,535	182,390	25.9	30.6	34.0	5,930	.....	3.815	585,687	XII—Slight.
23	22.40	+1.65	.....	.....	.....	.....	.....	.....	.....	.....	.....	
24	23.80	+1.40	170,565	181,295	29.0	30.4	36.0	5,956	—1,095	4.000	682,280	III—Slight.
25	25.10	+1.30	178,795	181,779	30.0	30.4	38.0	5,965	+ 484	4.031	720,636	II—Slight.
26	25.60	+0.50	185,910	185,910	31.2	31.2	39.0	5,966	+4,131	4.057	754,326	Calm.
27	25.60	0.00	187,650	187,650	31.5	31.5	39.0	5,967	+1,740	4.055	760,899	VI—Slight.
28	25.35	—0.25	187,460	188,952	31.4	31.7	39.5	5,967	+1,302	4.000	749,665	XI—Slight.
Mar. 1	25.00	—0.35	183,670	187,249	30.8	31.4	38.8	5,962	—1,703	4.009	736,346	XII—Slight.
2	24.35	—0.65	179,040	186,499	30.0	31.2	38.0	5,958	— 750	3.940	705,026	I—Slight.
4	22.90	—1.45	168,000	184,087	28.3	30.9	38.0	5,948	—2,412	3.855	647,936	I—Slight.
5	22.70	—0.20	167,240	184,515	28.1	30.9	37.0	5,947	+ 438	3.826	639,933	XI—Mild.
6	22.70	—0.00	166,825	184,100	28.0	30.9	37.5	5,947	— 415	3.837	640,172	XII—Slight.
7	22.65	—0.05	167,410	184,983	28.2	31.0	36.7	5,947	+ 883	3.819	639,283	XII—Slight.
8	22.45	—0.20	165,975	184,740	27.9	31.0	38.0	5,944	— 243	3.770	624,932	XI—Mild.
9	21.70	—0.75	163,380	186,589	27.5	31.3	37.5	5,934	+1,849	3.751	612,793	XI—Mild.
11	20.23	—1.47	155,045	186,980	26.2	31.4	35.7	5,927	+ 391	3.651	566,100	VI—Slight.
12	19.65	—0.58	149,510	184,897	25.2	31.0	35.3	5,928	—2,083	3.638	543,910	XII—Slight.
13	19.10	—0.55	145,840	184,483	24.7	30.9	34.7	5,918	— 414	3.628	528,894	VI—Slight.
14	18.80	—0.30	143,645	184,064	24.3	30.8	34.0	5,915	— 419	3.614	519,161	VI—Slight.
15	18.40	—0.40	141,630	184,417	24.0	30.9	33.7	5,914	+ 353	3.559	504,050	VI—Slight.
16	17.95	—0.45	139,050	184,500	23.6	30.9	32.7	5,912	+ 83	3.547	493,232	VI—Slight.
18	17.23	—0.72	131,590	181,404	22.3	30.4	32.0	5,905	—3,096	3.529	463,943	VI—Slight.
19	16.70	—0.53	129,920	182,758	22.0	30.6	31.8	5,904	+1,354	3.602	467,779	XII—Strong.
20	16.50	—0.20	127,375	181,393	21.6	30.4	31.0	5,902	—1,365	3.433	437,374	XII—Mild.
21	16.25	—0.25	125,350	180,843	21.3	30.3	31.5	5,900	— 550	3.402	426,471	XII—Slight.
22	16.18	—0.07	125,115	180,636	21.2	30.3	30.5	5,898	— 207	3.392	424,272	III—Slight.
23	16.75	+0.57	128,280	180,818	21.7	30.3	31.0	5,902	+ 182	3.455	443,187	XII—Slight.
25	18.95	+2.20	141,290	180,822	23.9	30.3	33.0	5,919	+ 4	3.598	508,276	I—Slight.
26	19.37	+0.42	144,300	181,346	24.4	30.4	33.7	5,925	+ 524	3.690	531,697	VI—Slight.
27	19.35	—0.02	.....	.....	.....	.....	.....	.....	.....	.....	.....	
28	19.05	—0.30	143,530	182,473	24.2	30.6	33.3	5,925	+1,127	3.673	527,208	X—Slight.
29	18.63	—0.42	141,100	182,529	23.8	30.6	33.5	5,920	+ 56	3.672	518,084	VI—Moderate.
30	18.03	—0.60	137,770	182,747	23.3	30.6	32.0	5,912	+ 218	3.618	498,321	XII—Slight.
Apr. 1	17.27	—0.76	131,305	180,777	22.2	30.3	31.5	5,909	—1,970	3.573	469,445	XII—Strong.
2	16.78	—0.49	128,520	180,880	21.7	30.3	31.0	5,901	+ 103	3.441	442,305	XII—Slight.
3	16.30	—0.48	126,100	181,289	21.4	30.6	30.3	5,896	+ 409	3.463	436,737	XII—Slight.
4	16.10	—0.20	123,200	179,572	20.9	30.1	30.3	5,896	—1,717	3.420	421,334	XII—Slight.
5	16.08	—0.02	123,100	179,591	21.4	30.1	30.3	5,896	+ 19	3.424	421,725	VI—Mild.
6	16.18	+0.10	123,220	179,119	20.9	30.0	30.3	5,896	— 472	3.441	424,003	I—Mild.
8	16.23	+0.05	123,855	179,460	21.0	30.0	30.5	5,897	+ 341	3.439	425,915	VI—Slight.
9	15.88	—0.35	122,942	180,611	20.9	30.3	30.5	5,894	+1,151	3.418	420,261	VI—Slight.

Results of discharge observations, Mississippi River, New Madrid, Missouri, 1888-1889*—Continued.

METHOD.—Meter at sixth-tenths depth from the surface.

Date.	Gauge.		Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
			Area.		Depth.			Width.				
	Reading.	Rise or fall in the preceding 24 hours.†	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1889.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	
Apr. 10	15.47	—0.41	120,450	180,538	20.4	30.2	30.3	5,892	— 73	3.383	407,431	VI—Slight.
11	15.10	—0.37	118,715	180,985	20.2	30.3	29.7	5,890	+ 447	3.382	401,527	VI—Strong.
12	14.75	—0.35	116,740	181,081	19.8	30.4	29.7	5,889	+ 96	3.351	391,134	VI—Strong.
13	14.60	—0.15	115,180	180,400	19.6	30.2	29.7	5,887	— 681	3.295	379,715	XI—Slight.
15	14.10	—0.50	112,140	180,299	19.1	30.2	29.0	5,883	— 101	3.296	369,866	VI—Slight.
16	13.85	—0.25	109,695	179,322	18.7	30.0	28.0	5,880	— 977	3.290	361,620	V—Slight:
17	13.65	—0.20	107,790	178,598	18.4	29.9	27.3	5,880	— 724	3.276	353,167	XII—Slight.
18	14.15	+0.50	108,780	176,648	18.5	29.6	28.0	5,883	—2,150	3.329	362,076	VI—Moderate.
19	14.93	+0.78	113,230	176,510	19.2	29.6	28.8	5,892	— 138	3.364	380,901	VI—Mild.
20	15.65	+0.72	117,095	176,137	19.9	29.5	29.7	5,899	— 373	3.421	401,596	VII—Slight.
22	16.58	+0.93	121,735	175,286	20.6	29.4	31.0	5,905	— 851	3.502	426,389	III—Slight.
23	16.97	+0.42	124,975	176,221	21.2	29.5	31.0	5,908	+ 935	3.512	438,580	III—Slight.
24	17.55	+0.58	128,420	176,238	21.8	29.5	32.0	5,912	+ 17	3.587	460,685	IX—Slight.
25	18.33	+0.78	132,675	175,882	22.4	29.5	33.2	5,919	— 356	3.654	484,839	XI—Slight.
26	18.60	+0.27	136,620	178,229	23.1	29.9	34.0	5,924	+2,347	3.674	501,817	XII—Slight.
27	18.35	—0.25	135,125	178,214	22.8	29.9	33.5	5,921	— 15	3.644	492,323	X—Moderate.
29	16.00	—2.35	122,660	179,631	20.8	30.1	31.5	5,899	+1,417	3.447	422,967	VII—Mild.
30	14.75	—1.25	115,430	179,769	19.6	30.1	29.0	5,890	+ 138	3.363	388,279	XII—Mild.
May 1	13.70	—1.05	108,750	179,263	18.5	30.0	27.8	5,880	— 506	3.291	357,981	XII—Mild.
2	12.70	—1.00	102,420	178,824	17.4	29.9	26.3	5,876	— 439	3.257	333,734	XII—Mild.

* From reduction at office of first district engineer.

† Where a day is omitted the rise or fall given on the following day is for 48 hours.

Results of discharge observations, Mississippi River, below New Madrid, Missouri.

Date.	New Madrid gauge.		Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	No. of velocity stations.	No. of soundings.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.						
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1890.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*			
Mar. 25	36.6	0.0	239,698	173,472	39.5	28.8	51.8	6,066	.....	5.546	1,329.387	XI—Slight....	12	37
Apr. 8	37.7	—0.2	246,492	172,984	40.3	28.8	52.0	6,114	— 488	.....	.....	VI—Brisk	.....	48
9	37.3	—0.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	36.9	—0.4	240,893	172,525	39.5	28.7	53.0	6,106	— 459	5.290	1,274,319	X—Brisk	22	65
11	36.2	—0.7	236,028	171,558	38.7	28.5	52.5	6,091	— 967	5.231	1,234,597	VI—Brisk	23	67
12	35.6	—0.6	233,081	172,879	38.3	28.7	53.0	6,085	+1,321	5.209	1,214,031	VII—Brisk ...	23	65
13	34.9	—0.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	34.2	—0.7	226,213	174,597	37.3	29.0	52.0	6,058	+1,718	4.746	1,073,506	XII—Brisk ...	23	65

Discharge measurements were at high-water section of 1888–'89; datum line taken at same elevation as in that series.

Price meter No. 10, used at six-tenths depth from the surface for mean velocity at each velocity station; meter was rated April 11, 1890, and the resulting value of the constants, $a = 3.9897$, $b = +0.2986$, were used in computing discharges.

E. L. Harman, assistant engineer, chief of party.

EXTRACTS FROM REPORT OF MR. WILLIAM GERIG, ASSISTANT ENGINEER, UPON OFFICE REDUCTION OF DISCHARGE OBSERVATIONS, MISSISSIPPI RIVER, AT HELENA, ARKANSAS, 1888–'89.

MEMPHIS, TENN., *February* 20, 1890.

* * * * * * *

The co-efficients to be used in reducing the registrations of the meter to velocity in feet per second, were determined by causing the meter to move through still water, over a known distance, at various velocities, the time and number of registrations being noted.

* * * * * * *

The observations* were reduced by the method of least squares. * * * In the final reduction the widths were calculated and the soundings plotted on cross-section sheets, as were also the velocities. The total area was divided into partial areas and these were calculated by counting the squares, and were multiplied by the mean velocities of the partial areas which were taken from the cross-section sheets. The product was the partial discharge, and the sum of the partial discharges gave the total discharge, and this divided by the total area gave the mean velocity. The counting of the registrations was done in the field and checked. The results of computation were copied in a tabular form accompanying this report and also into the note-books. The gauge-readings correspond to the mean time of observation. The gauge was read at the beginning and ending of the day's work. The rise or fall for twenty-four hours is the difference in the mean gauge-reading for that day and the preceding one.

The computation of datum areas has been made in the following manner: The datum was assumed to correspond to the gauge-reading of 32.32 feet; the datum width was taken as 4,818 feet, that being the measured width and gauge-reading on March 2, 1889. The slope of the banks down to 21 feet on gauge was uniform, also from 21 to 19 feet, from 19 to 13 feet, and below 13 feet, and the datum areas have been computed by the formula:

$$\text{Datum area} = (32.32 - h)\ \frac{4818 + w}{2} + \text{water area},$$

where h = gauge and w = width.

The formula between 21 and 19 feet on gauge becomes:

$$\text{Datum area} = (32.32 - 21)\ \frac{4818 + 4700}{2} + (21 - h)\ \frac{4700 + w}{2} + \text{water area}$$

$$= 53872 + (21 - h)\ \frac{4700 + w}{2} + \text{water area},$$

in which 4,700 feet is the width for 21-foot stage.

For stages between 19 and 13 feet:

$$\text{Datum area} = 53872 + (21 - 19)\ \frac{4700 + 3392}{2} + (19 - h)\ \frac{3392 + w}{2} + \text{water area}$$

$$= 61964 + (19 - h)\ \frac{3392 + w}{2} + \text{water area},$$

in which 3,392 feet is the width at 19-foot stage.

For stages below 13 feet the formula becomes:

$$\text{Datum area} = 61964 + (19 - 13)\ \frac{3392 + 2705}{2} + (13 - h)\ \frac{2705 + w}{2} + \text{water area}$$

$$= 80255 + (13 - h)\ \frac{2705 + w}{2} + \text{water area},$$

in which 2,705 feet is the width at 13-foot stage.

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* For date of observations, etc., see Mr. Sturtevant's report herewith.

The mean depth has been obtained by dividing the water area by the width, and the mean datum depth has been obtained by dividing the datum area by the datum width. Maximum depth was taken directly from the notes. Scour or fill has been obtained by taking the difference of the datum areas, scour indicated by the positive sign. The direction of the wind is indicated by dividing the horizon into twelve parts and numbering the parts the same as the hours on a clock dial, XII being up-stream and indicating a down-stream wind.

The entire work has been checked in various ways and great care has been taken to eliminate all errors of computation.

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Capt. SMITH S. LEACH,
Corps of Engineers, U. S. A.,
Memphis, Tenn.

Results of discharge observations, Mississippi River, Helena, Arkansas, 1888–1889.*

[Method.—Meter.]

Date.	Gauge.		Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
			Area.		Depth.			Width.				
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1888.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	
Nov. 28	26.70	−0.50	133,997	160,832	28.3	33.2	75.0	4,732	.....	4.219	565,310	XII—Light.
29	25.98	−0.72	129,545	159,796	27.4	33.2	72.0	4,725	− 1,036	4.390	568,714	VIII—Very light.
30	24.95	−1.03	125,124	160,278	26.5	33.2	74.4	4,722	+ 482	4.383	548,408	X—Moderate.
Dec. 1	23.81	−1.14	118,436	158,999	25.1	33.0	72.0	4,715	− 1,279	5.381	518,854	XI—Moderate.
2	22.40	−1.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	21.12	−1.28	107,901	161,213	22.9	33.5	73.0	4,702	+ 2,214	4.570	493,081	VIII—Moderate.
4	19.87	−1.25	98,462	156,970	28.1	32.6	74.0	3,505	− 4,243	4.641	456,952	IV—Very light.
5	18.57	−1.30	92,620	156,011	28.5	32.5	71.0	3,244	− 959	4.773	442,074	VI—Light.
6	17.29	−1.28	88,600	156,106	28.6	32.5	67.0	3,090	+ 95	4.719	418,138	XII—Moderate.
7	15.99	−1.30	83,572	155,000	28.5	32.2	68.0	2,938	− 1,106	4.402	367,930	IV—Moderate.
8	14.74	−1.25	81,521	156,859	28.3	32.6	68.5	2,887	+ 1,859	4.097	333,977	IV—Moderate.
9	13.60	−1.14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	12.70	−0.90	69,929	150,992	26.1	31.3	61.0	2,680	− 5,867	4.063	284,144	XII—Light.
11	11.82	−0.88	67,645	151,071	25.3	31.4	64.0	2,670	+ 79	3.927	265,627	I—Very light.
12	11.06	−0.76	67,315	152,780	25.2	31.7	61.2	2,666	+ 1,709	4.057	273,108	II—Very light.
13	10.50	−0.56	65,424	152,267	25.5	31.6	62.3	2,565	− 513	4.101	268,752	VII—Moderate.
14	9.97	−0.53	64,097	152,245	25.6	31.6	62.5	2,505	− 22	3.949	253,139	XII—Very light.
15	9.50	0.47	.....	.....	.....	.....	.....	.....	.....	.....	.....	IV—Strong.
16	9.42	−0.08	61,910	151,482	24.8	31.4	60.2	2,500	− 763	3.931	243,358	VII—Light.
17	9.35	−0.07	62,485	152.239	25.0	31.6	62.3	2,500	+ 757	3.931	245,623	IX—Light.
18	9.24	−0.11	62,567	152,607	25.0	31.7	61.0	2,500	+ 368	3.830	239,577	IX—Light.
19	9.06	−0.17	61,395	151,884	24.7	31.5	60.0	2,490	− 723	3.908	239,947	XI—Light.
20	8.99	−0.08	61,990	152,631	25.0	31.7	60.0	2,475	+ 747	3.893	241,337	VI—Light.
21	8.93	−0.06	60.440	151,231	24.5	31.4	60.0	2,473	− 1,400	3.915	236,656	
22	8.95	+0.02	60.155	150,889	24.4	31.3	60.0	2,470	− 342	3.824	229,064	I—Very light.
23	9.25	+0.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
24	9.62	+0.37	61,450	150,401	24.6	31.2	56.0	2,500	− 488	3.928	241,347	IV—Light.
25	10.25	+0.63	63,730	151,204	24.9	31.4	58.2	2,555	+ 803	3.954	251,951	IV—Very light.
26	10.96	+0.71	64,828	150,442	25.3	31.2	59.0	2,562	− 762	4.209	272,842	IX—Very strong.
27	11.44	+0.47	66,284	150,693	25.3	31.3	59.0	2,620	+ 251	4.130	273,787	IX—Moderate.
28	11.69	+0.25	67,913	151,682	25.4	31.4	60.0	2,680	+ 989	4.133	280,641	XII—Moderate.
29	11.95	+0.26	69,955	153,024	26.1	31.8	60.0	2,680	+ 1,342	4.120	288,827	XII—Light.
30	12.45	+0.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
31	13.10	+0.65	71,752	151,702	26.5	31.4	61.0	2,705	− 1,322	4.143	297,185	XII—Light.

	1889.											
Jan.	1	13.92	+0.82	75,125	152,779	27.0	31.7	3.0	2,785	+ 1,077	4.233	317,972	XII—Moderate.
	2	14.85	+0.23										
	3	15.34	+0.49	80,594	154,035	28.0	31.9	63.7	2,888	+ 1,256	4.240	341,753	II—Light.
	4	15.62	+0.28										
	5	15.60	−0.02	79,631	152,340	27.1	31.6	64.0	2,938	− 1,695	4.354	346,734	XI—Light.
	6	15.25	−0.35										
	7	14.86	−0.39	77,343	152,307	26.5	31.6	63.5	2,888	− 33	4.227	326,859	VI—Light.
	8	14.48	−0.38	76,572	152,670	26.7	31.7	63.2	2,862	+ 363	4.172	319,416	Fog.
	9	14.49	−0.01	77,331	153,398	27.0	31.8	63.7	2,862	+ 728	4.292	331,911	VIII—Strong.
	10	14.74	+0.25	77,153	152,446	26.9	31.6	63.0	2,873	− 952	4.234	326,684	VII—Very light.
	11	15.39	+0.65	80,059	153,379	27.5	31.8	62.8	2,908	+ 933	4.472	358,036	Calm.
	12	16.40	+1.01	84,127	154,430	28.2	32.0	65.3	2,989	+ 1,051	4.483	377,117	IV—Light.
	13	18.00	+1.60										
	14	19.65	+1.65	94,574	153,909	27.9	31.9	67.0	3,394	− 521	4.773	450,361	XII—Light.
	15	21.95	+2.30					71.2					IV—Moderate.
	16	24.32	+2.37	127,275	165,323	27.1	34.4	75.0	4,700	+11,414	4.741	603,411	VII—Moderate.
	17	25.56	+1.23	131,624	163,876	27.8	34.0	78.0	4,724	− 1,447	4.781	629,580	XII—Moderate.
	18	26.36	+0.80	133,914	162,355	28.1	33.7	78.0	4,734	− 1,521	4.630	619,969	
	19	27.03	+0.66	137,962	163,248	29.1	33.9	78.5	4,742	+ 893	4.635	639,500	II—Light.
	20	27.98	+0.95										
	21	28.65	+0.67	141,163	158,726	29.6	33.0	77.5	4,766	− 4,522	4.650	656,457	Calm.
	22	29.50	+0.85	145,823	159,028	30.5	33.1	79.0	4,777	+ +302	4.700	685,324	VI—Light.
	23	30.40	+0.89	151,100	160,313	31.6	33.2	80.0	4,779	+ 1,285	5.016	757,926	I—Light.
	24	31.15	+0.75	161,333	166,931	33.7	34.7	80.0	4,792	+ 6,618	4.797	773,807	II—Light.
	25	31.35	+0.20										I—Fog.
	26	31.25	−0.10										Fog.
	27	30.85	−0.40	149,397	156,383	31.2	32.5	79.5	4,787	−10,548	4.658	695,785	VIII—Strong.
	28	30.10	−0.75	150,039	160,687	31.4	33.3	79.5	4,775	+ 4,304	4.696	704,632	X—Very strong.
	29	29.14	−0.96	142,318	157,556	29.9	32.7	79.5	4,766	− 3,131	4.697	668,387	IX—Light.
	30	28.06	−1.08	134,860	155,250	28.4	32.3	77.0	4,755	− 2,306	4.596	619,811	V—Moderate.
	31	27.25	−0.80	132,382	156,595	27.9	32.6	75.0	4,743	+ 1,345	4.553	602,791	I—Very light.
Feb.	1	26.86	−0.39	131,322	157,407	27.7	32.7	75.0	4,737	+ 812	4.503	591,403	I—Very light.
	2	26.88	+0.02	133,727	159,701	28.2	33.2	77.0	4,740	+ 2,294	4.468	597,532	VII—Moderate.
	3	27.25	+0.37										
	4	27.79	+0.54	136,612	158,273	28.7	32.7	76.0	4,756	− 1,428	4.709	643,403	VI—Light.
	5	28.44	+0.64	139,858	158,445	29.4	32.8	75.2	4,763	+ 172	4.581	640,760	X—Strong.
	6	29.01	+0.57	140,845	156,699	29.5	32.6	75.5	4,776	− 1,746	4.674	657,797	XII—Strong.
	7	29.33	+0.31	142,372	156,717	29.8	32.6	77.0	4,777	+ 18	4.713	671,028	VI—Moderate.
	8	29.28	−0.05	144,432	159,029	30.2	33.1	77.2	4,780	− 2,312	4.750	684,051	VII—Light.
	9	28.95	−0.33	142,580	158,749	29.8	32.9	76.0	4,778	− 280	4.600	655,905	XI—Light.
	10	28.08	+0.87										
	11	27.03	−1.05	134,209	159,567	28.2	33.2	76.0	4,769	+ 818	4.414	592,456	IX—Moderate.
	12	25.62	−1.41	128,352	160,331	27.6	33.3	75.0	4,728	+ 764	4.334	556,252	IX—Light.
	13	23.90	−1.72	116,969	157,098	24.8	32.6	75.0	4,714	− 3,233	4.417	516,585	VII—Strong.
	14	22.06	−1.83										Heavy fog.
	15	20.13	−1.93										Heavy fog.
	16	18.60	−1.53	89,396	152,699	27.1	31.7	67.0	3,293	− 4,399	4.354	389,193	VI—Moderate.

* From reduction at office of second district engineer.

Results of discharge observations, Mississippi River, Helena, Arkansas, 1888–1889*—Continued.

[METHOD.—Meter.]

Date.	Gauge.		Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.				
			Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1889.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	
Feb. 17	17.18	—1.42										
18	16.19	—0.99	83,028	154,042	27.1	32.0	65.0	3,061	+ 1,343	4.261	353,797	XI—Strong.
19	15.18	—1.01	80,428	154,554	26.9	32.0	64.0	2,984	+ 512	4.205	338,195	XI—Moderate.
20	14.51	—0.67	76,823	152,859	36.6	31.7	62.3	2,883	— 1,695	4.187	321,689	IV—Light.
21	14.69	+0.17	77,802	153,289	27.0	31.8	64.0	2,883	+ 430	4.391	341,645	V—Very light.
22	16.60	+1.91	83,215	152,921	27.1	31.7	66.0	3,073	— 368	4.601	382,856	VII—Light.
23	20.54	+3.94	†100,408	156,236	25.8	32.5	70.5	3,897	+ 3,315	†4.951	†497,161	XII—Strong.
24	23.85	+3.31										
25	25.96	+2.11	129,085	159,427	27.3	33.2	74.2	4,731	+ 3,191	4.730	610,507	XI—Moderate.
26	27.93	+1.96	140,113	161,130	29.4	33.4	75.6	4,757	+ 1,703	4.795	671,820	VI—Very light.
27	29.54	+1.61	147,967	161,308	30.9	33.5	77.0	4,780	+ 178	4.892	723,872	VI—Light.
28	30.95	+1.41	155,742	162,332	32.4	33.7	79.5	4,802	+ 1,024	4.856	756,200	Fog.
Mar. 1	31.72	+0.77					79.0	4,809				Fog.
2	32.32	+0.60	164,099	164,099	34.1	34.1	81.2	4,818	+ 1,767	4.873	799,657	XII—Moderate.
3	32.30	—0.02										
4	32.09	—0.21	163,218	164,301	33.9	34.2	80.5	4,810	+ 202	4.569	745,773	XII—Very light.
5	31.65	—0.44	160,826	164,049	33.5	34.1	80.0	4,804	— 252	4.606	740,737	XI—Moderate.
6	31.14	—0.51	154,837	165,511	32.3	33.3	78.0	4,800	— 3,538	4.562	706,082	VIII—Light.
7	30.75	—0.39	154,370	161,912	32.2	33.6	78.0	4,790	+ 1,401	4.583	707,517	XI—Light.
8	30.41	—0.34	151,528	160,699	31.7	33.3	78.0	4,785	— 1,213	4.474	677,952	X—Moderate.
9	30.26	—0.15	150,585	160,475	31.5	33.3	78.0	4,784	— 224	4.452	670,488	XI—Strong.
10	29.93	—0.33										
11	29.46	—0.47	144,604	158,304	30.3	32.9	76.3	4,779	— 2,171	4.388	634,548	VI—Very light.
12	28.75	—0.71	141,278	158,382	29.7	32.9	75.5	4,764	+ 78	4.392	620,471	VI—Very light.
13	27.94	—0.81	137,461	158,424	28.8	32.9	75.0	4,754	+ 42	4.377	601,689	I—Light.
14	27.02	—0.92	132,030	157,388	27.8	32.7	75.0	4,751	— 1,036	4.430	584,788	V—Very light.
15	26.12	—0.89	127,405	156,995	26.9	32.6	73.5	4,735	— 393	4.363	555,891	
16	25.52	—0.60	124,891	157,351	26.4	32.7	72.0	4,729	+ 356	4.343	542,347	IX—Light.
17	24.83	—0.69										
18	24.43	—0.40	118,029	155,568	25.0	32.2	72.0	4,723	— 1,783	4.428	522,693	VI—Light.
19	24.05	—0.38	117,766	157,210	25.0	32.7	71.0	4,721	+ 1,642	4.355	512,825	XII—Strong.
20	23.55	—0.50	114,676	156,482	24.3	32.6	70.5	4,716	— 728	4.403	504,617	XII—Light.
21	22.90	—0.65	111,118	156,009	23.6	32.5	72.0	4,713	— 473	4.271	474,499	I—Light.
22	22.30	—0.60	108,466	156,211	23.0	32.5	69.5	4,712	+ 202	4.239	459,830	II—Moderate.
23	21.81	—0.49	105,845	155,884	22.5	32.4	68.0	4,708	— 327	4.342	459,589	III—Light.

	24	21.50	−0.31									
	25	21.79	+0.29	105,570	155,701	22.4	32.4	68.5	4,708	− 183	4.414	466,027	XII—Light.
	26	22.60	+0.80	112,424	158,749	23.9	32.9	70.5	4,714	+3,048	4.440	499,114	XI—Very light.
	27	23.79	+1.19	117,662	158,346	24.9	32.7	71.0	4,721	− 403	4.402	517,928	X—Light.
	28	24.83	+1.04	123,032	158,793	26.0	32.9	72.0	4,731	+ 447	4.449	547,395	XII—Light.
	29†	25.42	+0.59										V—Moderate.
	30†	25.45	+0.03										
	31‡	25.28	−0.17										
Apr.	1	25.23	−0.05	125,675	159,506	26.5	33.2	74.0	4,732	+ 713	4.419	555,337	XI—Moderate.
	2	25.02	−0.21										
	3	24.51	−0.51	120,930	158,180	25.6	32.7	71.8	4,721	−1,326	4.284	518,094	X—Light.
	4	24.02	−0.49										
	5	23.35	−0.67	115,946	158,692	24.6	32.9	72.3	4,713	+ 512	4.344	503,592	XI—Very light.
	6	22.69	−0.65	114,103	159,961	24.2	33.3	72.0	4,711	+1,269	4.285	488,943	XII—Strong.
	7	22.23	−0.46										
	8	21.95	−0.28	110,423	159,815	23.5	33.2	72.0	4,708	− 146	4.239	468,049	X—Very light.
	9	21.90	−0.05	110,777	160,402	23.5	33.3	72.5	4,707	+ 587	4.338	480,477	VI—Light.
	10	21.82	−0.08	111,022	161,028	23.6	33.4	73.0	4,707	+ 626	4.317	479,300	VIII—Very light.
	11	21.65	−0.17	110,622	161,438	23.5	33.5	73.5	4,707	+ 410	4.273	472,722	VII—Light.
	12	21.20	−0.45										Very strong.
	13	20.84	−0.36	101,798	156,358	26.3	32.6	72.5	3,895	−5,080	4.347	442,536	XI—Moderate.
	14	20.23	−0.61										
	15	19.79	−0.44	98,330	157,240	28.2	32.7	70.0	3,495	+ 882	4.319	424,637	XII—Light.
	16	19.48	−0.31	95,727	155,729	28.2	32.4	69.1	3,393	−1,511	4.352	416,484	I—Very light.
	17	19.16	−0.32	94,389	155,685	27.9	32.4	70.0	3,392	− 44	4.445	419,562	VII—Very light.
	18	18.82	−0.34	92,040	154,593	27.5	32.0	69.0	3,341	−1,092	4.311	396,770	VI—Strong.
	19	18.49	−0.33	88,937	152,605	27.0	31.7	67.5	3,291	−1,988	4.442	395,048	VI—Strong.
	20	18.40	−0.09	88,657	152,626	26.9	31.7	66.7	3,291	+ 21	4.346	385,319	X—Very light.
	21	18.80	+0.40										
	22	19.45	+0.65	94,082	154,226	27.7	32.0	70.0	3,393	+1,600	4.486	423,969	I—Moderate.
	23	20.23	+0.78	96,714	153,818	26.2	31.9	70.3	3,694	− 408	4.413	426,760	XI—Very light.
	24	20.85	+0.62	102,239	156,817	21.7	32.6	69.8	4,708	+2,999	4.445	454,408	XII—Light.
	25	21.40	+0.55	105,466	157,478	22.4	32.8	71.0	4,708	+ 661	4.404	464,437	XII—Light.
	26	21.91	+0.51	108,068	157,648	22.9	32.8	69.2	4,712	+ 170	4.401	475,572	XI—Very light.
	27	22.67	+0.76	110,920	156,888	23.6	32.6	70.0	4.714	− 760	4.478	496,670	X—Moderate.
	28	23.25	+0.68										
	29	23.57	+0.22	114,358	156,065	24.3	32.5	71.0	4,715	− 823	4.455	509,474	X—Light.
	30	23.22	−0.35	113,752	157,122	24.1	32.7	70.2	4,714	+1,057	4.410	501,645	XI—Moderate.
May	1	22.27	−0.95	109,808	157,676	23.3	32.8	70.0	4,708	+ 554	4.267	468,497	X—Moderate.
	2	20.84	−1.43	102,363	156,987	21.9	32.7	68.5	4,702	− 689	4.273	437,446	XI—Moderate.

* From reduction at office of second district engineer.
† For February 23 the note-book gives these additional results for the chute: area, 4,002; mean velocity, 1,497; discharge, 5,991.
‡ Launch pump broken.

Results of discharge observations, Mississippi River, Arkansas City, Arkansas, 1887.

METHOD.—Meter at six-tenths depth from surface.

Date.	Gauge.		Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Remarks.	No. of velocity stations.	No. of soundings.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.						
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1887.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			
Mar. 22	46.59	+0.05	233,105	215,475	68.0	63.5	95.0	3,414	.....	6.122	1,427,177	.....	16	32
23	46.60	+0.05	233,667	216,003	68.1	63.6	97.0	3,414	+ 528	6.197	1,447,969	.....	16	40
24	46.61	0.00	247,404	229,701	72.1	67.7	97.0	3,416	+13,698	5.982	1,479,975	.....	16	42
25	46.63	+0.05	*240,852	.....	70.1	.....	.....	3,420	.....	5.839	1,406,309	.....	16?	.....
26	46.63	0.00	234,299	216,518	68.2	63.8	96.0	3,420	—13,183	6.079	1,424,320	a.m.....	16	69
										6.024	1,411,396	p.m.....	16	69

* Interpolated.

The widths tabulated were scaled from the plotted cross-sections, and were measured from bank to bank. There was a discharge beyond the banks which increased the water width by 320 feet, and the water area by 1,084 square feet; this overflow amounted to 1,666 cubic feet per second the first two days, a nd subsequently to 1,626 cubic feet per second. The areas and discharges given above include these quantities. The datum line was taken at 41.73 feet on the gauge, as in the series of 1884–'85, and datum width at 3,39 5 feet. For the meter rating see page 3151.

MEMORANDA TO ACCOMPANY TABULATED RESULTS OF FINAL REDUCTION IN SECRETARY'S OFFICE, MISSISSIPPI RIVER COMMISSION, OF DISCHARGE OBSERVATIONS MADE ON THE MISSISSIPPI RIVER AT ARKANSAS CITY, ARKANSAS, 1889.

OCTOBER 25, 1889.

The notes of these observations were received from the third district in May, 1889, for recomputation.

A map of the locality drawn to a scale of 1:7200 accompanied the notes. This map shows the discharge section at apparently the same place as it was in 1884–'85, and also shows the arrangement of fixed signals on shore by which the sounding and velocity stations were located. The sounding stations were at intervals of 75 feet across the river, every fourth one being also a velocity station. The water's edge at each bank was located by measuring from the section hub on that bank; this also determined the river width for that day.

All the velocities of this series were measured with the W. G. Price current meter, No. 5; for a description of the Price meter and outfit, see Report Chief of Engineers, 1887, page 2821. The chronograph slips did not accompany the notes; the registrations, however, had been counted in the field and recorded in the notes and the results were adopted in this computation. The observer states that on February 22 and 23, no paper being on hand, the revolutions of the meter wheel were found by watching the registering points.

Three sets of rating observations were made with this meter at Arkansas City during the season; the results of reduction in this office by the usual method are given in the following table:

Date of observations.	No. of observations.	*a*	*b*	Mean error of observations.	Mean error of *a*	Mean error of *b*	Remarks.
Dec. 4, 1888...	12	3.7989	+0.1943	±0.280	±0.121	±0.215	In running water.
Feb. 27, 1889..	15	3.9321	+0.0187	±0.188	±0.109	±0.165	Do.
Mar. 27, 1890 .	22	3.8421	+0.0785	±0.238	±0.075	±0.145	Do.

These results were combined by weighting *a* and *b* inversely as the squares of the mean errors of *a* and *b* in each series; the resulting equation, $y = 3.8712\,x + 0.0816$, was used in computing all of the 1889 series of discharges at this station.

(In 1884–'85 six sets of rating observations were made with this meter; the results are published in Report Chief of Engineers, 1887, page 2815. Also a set of rating observations was made with this meter near Wilson's Point, La., July 4, 1889; the results are published herewith.)

The computations of areas of cross-section were made and checked in the manner described at length in Report Chief of Engineers, 1887, pages 2823–2826. There were no lead-line corrections and the soundings were taken directly from the note-books.

The discharges were found by the method described in the report accompanying the final reduction in Secretary's office of the Carrollton observations of 1883. In the present series, however, the meter was usually run at six-tenths the depth from the surface, and for 150 seconds.

The datum areas were computed in the following manner: Datum was assumed at 41.73 feet on the gauge; this was the elevation of datum in 1884–'85 and was adopted in this work in order to conveniently make comparisons between the different series. Datum width was taken as 3,395 feet. The width at 35.25 feet on the gauge was taken as observed, as 3,373 feet; at 29 feet, as 3,363 feet, before February 15; after that date as 3,352 feet; at 22.67 feet, as 3,321 feet. The following formulas were used in computing the datum areas, in which h represents gauge-reading and w observed width.

Between 29 and 35.25 feet on the gauge:

$$\text{Datum area} = (41.73 - 35.25)\,\frac{3395 + 3373}{2} + (35.25 - h)\,\frac{3373 + w}{2} + \text{water area}$$

$$= 21928 + (35.25 - h)\,\frac{3373 + w}{2} + \text{water area.}$$

Between 22.67 and 29 feet on the gauge:

$$\text{Datum area} = 21928 + (35.25 - 29)\,\frac{3373 + {}^{*}3352}{2} + (29 - h)\,\frac{{}^{*}3352 + w}{2} + \text{water area}$$

$$= 42944 + (29 - h)\,\frac{{}^{*}3352 + w}{2} + \text{water area.}$$

* 3363 was used prior to February 15, 1889.

Below 22.67 on the gauge:

$$\text{Datum area} = 42944 + (29 - 22.67)\frac{*3352 + 3321}{2} + (22.67 - h) \times \frac{3321 + w}{2} + \text{water area}$$

$$= 64064 + (22.67 - h)\frac{3321 + w}{2} + \text{water area.}$$

The gauge used was the standard gauge at the elevator. The gauge inspectors' level notes of September 7, 1887, and October 4, 1889, show that this gauge was 0.2 foot too high, and all the records between those dates have been corrected by adding 0.2 foot to each reading. The zero of this gauge is 116.44 feet above the Cairo datum plane, survey Mississippi River.

The gauge-readings given for days on which the discharge section was sounded correspond to mean time of observations; for other days the mean daily reading is given. The rise or fall in preceding twenty-four hours is derived from the regular record.

The maximum depths have been taken directly from the soundings.

The direction and force of wind have been copied from the notes; the direction is indicated by the figures of a clock dial, XII o'clock being up-stream and denoting a down-stream wind, VI denoting an up-stream wind, etc.

The figures following the direction evidently indicate the velocity in miles per hour as they agree with Trautwine's wind-table which had been copied into one of the note-books.

The mean velocities, mean depths, mean datum depths, and scour and fill have been computed in the usual manner.

Accompanying the tables are two plates. On one is the map of the locality, and on the other the discharges, areas, and mean velocities as abscissas have been plotted to gauge heights, and the datum areas and gauge record plotted to time abscissas. On the latter plate are also plotted two profiles of the discharge cross-section.

Results of other discharge observations at this station are published as follows: October 6, 1884, to April 9, 1885, gauge-reading from 7.42 feet to 41.73 feet; report Mississippi River Commission, 1887, pages 2838–2840.

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* 3363 was used prior to February 15, 1889.

Results of discharge observations, Mississippi River, at Arkansas City, Arkansas, 1889.

METHOD.—Meter at six-tenths depth from the surface.

Date.	Gauge.		Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	No. of velocity stations.	No. of soundings.
	Reading.	Rise or Fall in the preceding 24 hours.	Area.		Depth.			Width.						
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1889.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			
Jan. 22	33.45	+0.80	183,640	211,638	54.5	62.3	81.0	3,371	.....	4.298	789,225	.....	11	44
23	34.10	+0.75	185,978	211,784	55.2	62.4	83.0	3,371	+ 146	4.805	893,714	.....	11	44
24	34.68	+0.65	190,945	214,795	56.6	63.3	83.0	3,372	+ 3,011	4.444	848,555	.....	9	45
25	35.20	+0.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	35.45	+0.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
27	35.50	+0.05	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	35.25	—0.25	191,391	213,319	56.7	62.8	85.0	3,373	— 1,476	4.707	900,919	VIII—30.....	11	45
29	35.05	—0.30	192,706	215,309	57.1	63.4	85.0	3,373	+ 1,990	4.326	833,659	VIII—10.....	11	45
30	34.55	—0.40	191,040	215,329	56.7	63.4	85.5	3,372	+ 20	4.421	844,502	II—5.....	11	46
31	34.10	—0.45	189,542	215,348	56.2	63.4	86.0	3,372	+ 19	4.302	815,354	XI—15.....	11	46
Feb. 1	33.65	—0.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	33.52	—0.20	187,332	215,094	55.6	63.4	84.5	3,371	— 254	4.542	850,838	II—3.....	11	46
3	33.30	—0.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	33.30	0.00	185,374	213,877	55.0	63.0	85.5	3,371	— 1,217	4.288	794,911	.....	11	45
5	33.35	+0.05	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	33.50	+0.20	179,841	207,671	53.3	61.2	83.0	3,372	— 6,206	4.412	793,375	.....	11	45
7	33.76	+0.30	178,559	205,512	53.0	60.5	81.5	3,372	— 2,159	4.375	781,219	IV—15.....	11	45
8	33.86	+0.05	179,757	206,573	53.3	60.8	83.0	3,372	+ 861	4.108	738,416	IV—15.....	11	45
9	33.80	—0.10	181,426	208,243	53 8	61.3	83.0	3,371	+ 1,870	4.261	773,052	XI—20.....	11	45
10	33.55	—0.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	33.07	—0.55	175,670	204,949	52.1	60.4	82.0	3,371	— 3,294	4.106	721,228	VII—5.....	11	45
12	32.25	—0.80	175,206	207,248	52.0	61.9	81.5	3,370	+ 2,299	4.111	720,230	VII—5.....	11	45
13	31.10	—1.10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	29.95	—1.30	167,948	207,740	49.9	61.2	78.0	3,368	+ 492	3.722	625,057	III—10.....	11	45
15	28.23	—1.40	160,195	205,761	47.7	60.6	78.5	3,360	— 1,979	.. ..	.....	III—5.....	.....	44
16	26.85	—1.35	142,706	192,845	42.7	56.8	68.5	3,341	—12,916	3.576	510,287	VI—3.....	44	44
17	25.40	—1.65	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
18	24.10	—1.45	133,014	192,319	40.0	56.6	67.5	3,326	— 526	.....	.....	IX—20.....	.....	44
19	22.67	—1.35	128,954	193,018	38.8	56.9	63.0	3,321	+ 699	3.225	415,822	XII—12½.....	11	44
20	21.53	—1.15	125,317	193,153	38.0	56.9	66.0	3,296	+ 135	3.240	406,072	II—10.....	11	44
21	20.61	—0.90	125,167	196,035	38.1	57.7	65.0	3,285	+ 2,882	3.232	404,531	XII—3.....	11	43
22	20.20	—0.35	123,943	196,164	37.7	57.8	65.5	3,284	+ 129	3.214	398,403	III—3.....	11	44
23	21.02	+1.00	127,570	197,084	38.8	58.1	66.0	3,285	+ 920	4.405	434,361	XII—20.....	11	44
24	23.50	+2.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Results of discharge observations, Mississippi River, at Arkansas City, Arkansas, 1889—Continued.

METHOD.—Meter at six-tenths depth from the surface.

Date.	Gauge.		Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	No. of velocity stations.	No. of soundings.
			Area.		Depth.			Width.						
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1889.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			
Feb. 25	25.53	+2.30	143,482	198,012	43.1	58.3	69.0	3,327	+ 928	3.708	531,990	X—5	11	44
26	27.59	+1.95	148,096	195,762	44.3	57.7	73.5	3,346	— 2,250	3.962	586,734	II—5	11	44
27	29.25	+1.70	156,287	198,393	46.6	58.4	73.5	3,353	+ 2,631	3.889	607,756	II—2	11	44
28	30.67	+1.35	160,090	197,434	47.7	58.2	74.0	3,359	— 959	3.967	635,103	II—2	11	44
Mar. 1	32.00	+1.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	Calm	.....	.....
2	32.83	+0.85	168,314	198,403	49.9	58.4	77.5	3,372	+ 969	4.150	698,573	.....	11	44
3	33.55	+0.70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	33.76	+0.30	167,612	194,568	49.6	57.3	78.0	3,376	—3,835	4.409	738,923	IX—5	11	44
5	34.08	+0.25	168,417	194,293	49.9	57.2	77.5	3,376	— 275	4.214	709,707	IX—15	11	44
6	34.53	+0.50	172,071	196,429	51.0	57.9	78.5	3,376	+2,136	4.345	747,641	V—10	13	44
7	34.86	+0.25	172,764	196,008	51.2	57.7	78.5	3,376	— 421	4.340	849,723	IX—12½	13	45
8	35.00	+0.15	172,162	194,934	51.0	57.4	78.0	3,377	—1,074	4.330	745,442	XI—10	13	45
9	34.96	0.00	173,814	196,721	51.5	57.9	78.0	3,377	+1,787	4.187	727,761	VIII—8	11	45
10	34.85	—0.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	34.63	—0.20	174,967	198,987	51.8	58.6	79.0	3,377	+2,266	4.176	730,743	XII—2	11	45
12	34.18	—0.50	174,508	200,047	51.7	58.9	81.0	3,376	+1,060	4.121	719,228	XI—2	12	44
13	33.61	—0.55	171,469	198,930	50.8	58.6	77.0	3,375	—1,117	4.072	698,281	.....	13	44
14	32.90	—0.75	168,204	198,060	49.9	58.3	74.5	3,374	— 870	4.038	679,285	Calm	13	44
15	32.11	—0.80	166,767	199,282	49.5	58.7	77.5	3,370	+1,222	4.003	667,581	VI—10	13	44
16	31.28	—0.80	162,766	198,065	48.4	58.3	76.5	3,363	—1,217	3.898	634,381	VII—5	13	44
17	30.35	—0.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
18	29.80	—0.55	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
19	29.03	—0.70	154,928	197,771	46.2	58.2	73.5	3,352	— 294	3.774	584,724	XI—12	14	44
20	28.61	—0.50	151,785	196,035	45.4	57.7	73.5	3,344	—1,736	3.693	560,548	X—3	15	44
21	28.05	—0.60	150,494	196,616	45.1	57.9	73.0	3,339	+ 581	3.721	559,923	X—4	15	44
22	27.46	—0.60	147,806	195,901	44.3	57.7	71.5	3,337	— 715	3.620	535,052	I—8	15	44
23	26.94	—0.50	147,378	197,210	44.2	58.1	72.0	3,335	+1,309	3.556	523,559	XI—5	15	44
24	26.65	—0.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	26.21	—0.40	144,973	197,244	43.5	58.1	70.5	3,334	+ 34	3.574	518,191	X—10	15	44
26	26.15	—0.05	144,894	197,366	43.5	58.1	70.5	3,334	+ 122	3.508	508,266	X—6	15	44
27	27.07	+0.65	147,695	197,093	44.3	58.1	71.0	3,336	— 273	3.715	548,655	V—5	15	44
28	28.41	+1.80	152,389	197,308	45.6	58.1	72.0	3,334	+ 215	3.899	594,094	XI—20	15	44
29	30.16	+1.60	157,690	196,741	47.0	58.0	74.0	3,355	— 567	3.976	626,972	II—10	15	44
30	31.24	+1.10	160,617	196,051	47.8	57.7	74.0	3,363	— 690	3.997	641,959	V—6	15	44
31	31.85	+0.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Apr.	1	32.09	+0.20	163,294	195,876	48.5	57.7	75.0	3,370	— 175	4.057	662,452	X—12	15	44
	2	32.10	+0.05	164,065	196,613	48.7	57.9	75.0	3,370	+ 737	3.998	655,934	IV—5	15	44
	3	32.00	—0.10												
	4	31.75	—0.25	164,658	198,383	48.9	58.4	45.0	3,368	+1,770	3.993	657,464	I—5	15	44
	5	31.40	—0.35	161,659	196,556	48.1	57.9	73.5	3,364	—1,827	3.871	625,704	I—5	15	44
	6	30.92	—0.40	160,870	197,366	47.9	58.1	73.0	3,356	+ 810	3.840	617,692	XII—10	15	44
	7	30.45	—0.55												
	8	29.93	—0.55	156,507	196,329	46.7	57.8	72.5	3,354	—1,037	3.733	584,234	IX—5		
	9	29.38	—0.45	159,303	200,969	47.5	59.2	74.5	3,352	+4,640	3.704	590,071			
	10	29.23	—0.20	155,646	197,816	46.4	58.3	73.5	3,352	—3,153	3.676	572,101		15	44
	*11	28.89	—0.30	153,858	197,171	45.9	58.1	73.5	3,352	— 645	3.739	575,218	VI—20		
	12	28.59	—0.35	152,437	196,754	45.6	58.0	72.5	3,344	— 417	3.788	577,328	V—20		
	†13	28.12	—0.45	150,587	196,475	45.1	57.9	72.5	3,340	— 279	3.623	545,538	III—6 to 20		
	14	27.70	—0.45												
	15	27.14	—0.60	146,868	196,032	44.0	57.7	72.0	3,336	— 443	3.533	518,825	XII—8		
	16	26.59	—0.50	144,939	195,941	43.5	57.7	70.0	3,335	— 91	3.521	510,298	II—8		
	17	26.04	—0.60	142,985	195,823	42.9	57.7	69.5	3,333	— 118	3.432	490,663	III—6	15	44
	18	25.44	—0.50	140,332	195,174	42.1	57.5	68.5	3,332	— 649	3.413	478,933	III—9		
	19	25.03	—0.45	137,961	194,167	41.4	57.2	69.0	3,329	—1,007	3.314	457,162	III—12 to 5		
	20	24.55	—0.55	135,174	192,979	40.6	56.8	68.5	3,327	—1,188	3.301	446,211			
	21	24.25	—0.25												
	22	24.27	—0.00	134,475	193,212	40.4	56.9	67.0	3,326	+ 233	3 312	445,337	XI—5		
	23	24.50	+0.30	133,873	191,845	40.2	56.5	66.5	3,327	—1,367	3.398	454,846	Variable—4		
	24	24.84	+0.30	135,676	192,516	40.8	56.7	67.0	3,329	+ 671	3.449	467,880	Var—Var	15	44
	25	25.18	+0.40	136,519	192,226	41.0	56.6	67.0	3,330	— 290	3.477	474,715	IX—5		
	26	25.63	+0.45	136,461	190,668	41.0	56.2	67.0	3,332	—1,558	3.487	475,849	XI—3		
	27	26.38	+0.75	139,156	190,859	41.7	56.2	69.0	3,334	+ 191	3.595	500,330	X—5		
	28	27.30	+0.85												
	29	27.87	+0.55	144,289	191,013	43.2	56.3	71.0	3,339	+ 154	3.638	524,935	IV—5	15	44
	30	28.10	+0.25												
May	1	27.86	—0.30	145,288	192,046	43.5	56.6	71.5	3,339	+1,033	3.587	521,209	XI—6	15	44

*Water very rough.

†Rain and hail storm.

MEMORANDA TO ACCOMPANY TABULATED RESULTS OF FINAL REDUCTION IN SECRETARY'S OFFICE, MISSISSIPPI RIVER COMMISSION, OF DISCHARGE OBSERVATIONS MADE AT WILSON'S POINT, LOUISIANA, 1883–1890, AND AT BREAK IN SKIPWITH LEVEE, MISSISSIPPI, 1890.

The discharge section was located at Wilson's Point Landing in November, 1883, and the same location, or about the same location, has been used throughout the different series to May 7, 1890. When first located the section crossed the head of Cottonwood Bar, but owing to the movement of the bar down-stream the form of the section has changed, and the caving of the banks has also increased the width of the section.

The methods used in this reduction are essentially the same as those heretofore employed in this office and fully described in the Annual Report Mississippi River Commission, 1887. A slight change, however, has been made since that report in computing the discharge, which has been found throughout this work as follows:

Each partial area was multiplied by the total number of meter registrations at the corresponding velocity station, and the sum of these products, after being reduced to registrations per second, was multiplied by the meter constant *a;* to this product was added the product of the total area into the meter constant *b;* the sum of these giving the total discharge when the meter had been run at the standard six-tenths depth from the surface.

The datum line was assumed at the same elevation throughout the different series 41.83 feet on the local gauge.

As the observations of the different years were not all under the same direction, the notes pertaining to the different periods are given as follows:

1883-1885.—Mr. E. D. Thompson, assistant engineer, chief of party.

A report on the field work of these observations to September 17, 1884, was published in the report of the Mississippi River Commission, 1884, page 270. The results of the first computation were published in the reports of the Commission, 1884 and 1885, pages 274 and 2968, respectively.

A copy of the field-notes of the whole series was received from the office of the third district in 1886 for recomputation in this office. Tracings of the cross-sections had previously been received from the third district, drawn to a scale of $1'' = 20'$ vertical and $1'' = 200'$ horizontal; the plotting of these was checked from the copy of field-notes above referred to, and made to agree with them.

The notes do not contain any record of tests of lead-line and give no lead-line corrections.

The W. G. Price current meter No. 4 was used in measuring all the velocities, the registrations or half revolutions were indicated by a telegraph sounder.

Observations were made for rating the meter November 26, 1883; February 25, 1884; April 12, 1884, and January 12, 1885.

All of these observations have been reduced in this office by the method of least squares; the results are given in the following table:

Date.	No. of observations.	*a*	*b*	e_o	e_a	e_b
November 26, 1883	20	2.1068	—0.076	±0.1573	±0.04916	±0.1061
February 25, 1884	12	2.1487	+0.2550	±0.3577	±0.2103	±1.4766
April 12, 1884	19	2.15805	+0.00157	±0.1021	±0.0349	±0.0260
January 12, 1885	32	2.06143	+0.1348	±0.0448	±0.0135	±0.0254
January 12, 1885	32	1.98372	+0.2195	±0.1609	±0.0561	±0.1143

The results of all these sets of observations were combined, the different values of the constants being given weight inversely as their probable errors, and the following resulting equation was used in computing all the discharges:

$$y = + 2.08\,x + 0.0703.$$

In discharge observations up to and including January 13, 1885, the meter had been run at mid depth, after that date at six-tenths depth from the surface.

It was necessary to correct the discharges so obtained up to January 13 to correspond to six-tenths depth velocity; and for this purpose the co-efficient (0.963) was adopted and applied. This ratio is based on the experimental work of 1882 at Helena,

Hays Landing, and Red River Landing. (See report Mississippi River Commission, 1884, page 189.)

As stated in the field report the velocity stations and soundings were definitely located, but frequently the notes were insufficient to locate the water's edge, and in such case the width of river was taken from the sheets of first computation.

For obtaining the areas of cross-sections, soundings were scaled from the plotted sections at each velocity station and at points midway between the stations; the sum of the distances between soundings was made to agree with the water width given in the notes. From these the areas were computed in the usual manner.

In computing datum areas, datum widths were assumed at 3,472 feet from November 27, 1883, to February 29, 1884, and 3,484 feet from March 3 to May 27, 1884, on and after June 11, 1884, at 3,520 feet. These changes in datum widths were necessitated by change of river width caused by caving banks. The datum areas were computed by the following formula:

Datum area $= (41.83 - h) \frac{W + W'}{2} +$ water area. In which w represents datum width, w' water width, and h reading on local gauge.

On January 26, 1885, two sets of velocity observations were made, one in the forenoon and one in the afternoon; the latter set show a large increase in the channel velocities. The observer states that the conditions under which both sets were made were apparently the same. Discharge for each set has been computed separately, using the same water area, and the results are given separately in the table.

1887-'88.—Mr. Arthur Hider, assistant engineer, chief of party.

1889.—Mr. E. C. Tollinger, assistant engineer, chief of party.

Datum width was taken as 3,555 feet for 1887 and 1888, and 3,546 feet for 1889. For the observations of 1887-'88 the first computation of water areas was checked by planimeter measurements, the sounding notes not being obtainable, and the water widths were scaled from the plotted cross-section.

The results of reduction in secretary's office of observations for rating the meters that were used in observing velocities are given in the following table:

Designation of meter.	Date and locality of rating observations.	Number of observations.	a	b	Mean error of observations.	Mean error of a.	Mean error of b.
Not given ...	April 18, 1887, Old River Lake.	10	+1.9921	+0.3769	±0.0825	±0.0251	±0.0832
Not given	April 23, 1887, Old River Lake.	15	+1.8941	+0.3448	±0.0671	±0.0145	±0.0493
Price, No. 5 ..	July 4, 1889, near Ashton, La.	11	+4.0704	+0.0417	±0.1735	±0.0810	±0.1341

Combining the results of April 18 and 23, 1887, by weighting the constants inversely as the squares of their mean errors, we have

$$y = 1.9186\,x + 0.353,$$

which was the equation used for reducing the observations at Arkansas City and Wilson's Point, 1887 and 1888.

For computing discharges, July 3–5, 1889, the results of rating July 4, given in the above table, were used.

1890.—Mr. F. P. Spalding, chief of party.

The results were obtained in the usual manner, except the discharge over bank east of section, which the observer states "was obtained by taking meter observations and soundings at approximately equal distances and averaging them to give a mean velocity and depth. The measurement of this discharge was not made on line of the section but in three separate parts." The results of the overflow discharge are from the field computation, the observation notes not having been received.

For velocity observations of January 28 and 31, and February 11 and 12 (except at one station on February 11), Price current meter No. 4 was used; the field-notes state that results of a rating previously made at Ashton are, $y = 1.921\,x + 0.321$, in which y = velocity in feet per second and x = registrations of meter per second. These values for this meter have been adopted in the final reduction.

For all other velocity observations Price meter No. 5 was used; 3 sets of rating ob-

servations were made with this meter during the season, the results of which, derived from final reduction in this office, are given in the following table:

Designation of meter.	Date and locality of rating observations.	No. of observations.	*a*	*b*	Mean error of observation.	Mean error of *a*.	Mean error of *b*.
Price meter No. 5.	Feb. 5, 1890, Duncansby, Miss...	*21	3.7581	+0.271	±0.124	±0.087	±0.151
	Feb. 26, 1890, Wilson's Point, La.	†24	3.7650	+0.2529	±0.048	±0.027	±0.045
	Apr. 11, 1890, Wilson's Point, La.	*29	3.791	+0.2042	±0.145	±0.084	±0.132

*In still water. †In running water.

It is reported that this meter was taken apart and cleaned on February 11, therefore the results of the first rating were used in computing discharges to February 11. For river discharges after that date the equation $y=3.7675\,x+0.2479$ was used; this was obtained by combining the results of ratings made February 26 and April 11, giving weight to the values of *a* and *b* inversely as the squares of their mean errors in the two series.

For computing discharges through the break in Skipwith levee, since the velocities were low, the results of April 11 rating were used, as they agree more closely with former ratings of this meter where low velocities were observed.

Datum was assumed at 41.83 feet on the local gauge as in computation of previous Wilson's Point discharge measurements.

OFFICE SECRETARY MISSISSIPPI RIVER COMMISSION,
May 30, 1890.

Results of discharge observations, Mississippi River, Wilson's Point, Louisiana.

METHOD.—Price meter, at mid-depth; observed velocities multiplied by 0.963 to reduce to six-tenths depth from the surface.

Date.	Gauges.			Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	No. of velocity stations.	No. of soundings.
				Area.		Depth.			Width.					
	Lake Providence.	Local.*	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.						
1883.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		
Nov. 27	17.9	.....	—0.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	18.4	23.00	+0.5	114,532	179,068	33.9	51.6	83.0	3,383	.....	4.287	490,949	20	41
Dec. 8	24.8	28.90	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	24.4	28.90	—0.2	131,875	176,193	39.0	50.7	85.0	3,383	— 2,875	4.892	645,188	12	62
1884.														
Jan. 30†	25.5	29.60	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	.....
31†	25.3	29.69	—0.2	129,949	172,129	37.9	49.6	75.0	3,425	— 4,064	5.027	653,251	11	53
Feb. 15	34.6	38.42	+0.6	160,309	172,139	46.2	49.6	86.0	3,467	+ 10	5.399	865,470	11	33
26	37.4	41.22	—0.4	176,264	178,382	50.8	51.4	88.0	3,472	+ 6,243	5.851	1,031,322	11	45
27	37.6	41.29	+0.2	172,814	174,689	49.8	53.2	86.0	3,472	— 3,693	6.128	1,058,945	11	39
28	37.6	41.35	0.0	172,855	174,521	49.8	50.3	88.0	3,472	— 168	5.878	1,015,993	11	31
29	37.7	41.40	+0.1	178,584	180,077	51.4	51.9	91.5	3,472	+ 5,556	5.799	1,035,667	11	44
Mar. 3	37.7	41.43	0.0	175,251	176,645	50.3	50.7	88.0	3,484	— 3,432	5.824	1,020,615	11	42
6	37.8	41.58	+0.1	180,344	181,215	51.8	52.0	88.0	3,484	+ 4,570	5.775	1,041,557	11	45
11	38.1	41.83	0.0	186,032	186,032	53.4	53.4	90.0	3,484	+ 4,817	6.098	1,134,373	11	47
13	38.2	41.78	0.0	183,017	183,191	52.5	52.6	89.0	3,484	— 2,841	6.026	1,102,799	11	59
17	37.8	41.58	0.0	184,563	185,434	53.0	53.2	87.0	3,484	+ 2,243	5.820	1,075,866	11	56
19	38.0	41.61	0.0	184,652	185,418	53.0	53.2	89.0	3,484	— 16	5.661	1,045,312	11	54
21	38.3	41.77	+0.2	186,930	187,139	53.7	53.7	89.0	3,484	+ 1,721	5.369	1,003,592	11	56
24	38.4	41.80	0.0	188,075	188,180	54.0	54.0	89.0	3,484	+ 1,041	5.572	1,047,887	12	55
26	38.3	41.67	0.0	186,222	186,779	53.5	53.6	86.5	3,484	— 1,401	5.434	1,011,849	11	57
28	38.1	41.53	—0.1	185,573	186,618	53.3	53.6	86.0	3,484	— 161	5.331	989,223	11	52
Apr. 5	37.1	40.80	—0.1	188,261	191,850	54.0	55.1	85.0	3,484	+ 5,232	5.415	1,019,427	11	53
12	36.7	40.55	0.0	188,173	192,633	54.0	55.3	85.5	3,484	+ 783	5.317	1,000,579	11	56
16	36.7	40.70	0.0	185,409	189,346	53.2	54.3	85.0	3,484	— 3,287	5.509	1,021,507	11	49
24	36.7	40.68	0.0	188,908	192,915	54.2	55.4	88.0	3,484	+ 3,569	5.373	1,015,038	11	52
May 3	36.5	40.45	0.0	190,696	195,504	54.7	56.1	88.0	3,484	+ 2,589	5.308	1,012,169	11	56
10	36.5	40.55	0.0	182,895	187,355	52.5	53.8	86.0	3,484	— 8,149	5.293	967,981	11	81
16	36.4	40.35	—0.1	186,487	191,643	53.5	55.0	85.5	3,484	+ 4,288	5.312	990,695	11	78
27	34.5	38.45	—0.4	182,876	194,649	52.5	55.9	85.0	3,482	+ 3,006	4.871	890,739	11	60
June 11	24.5	29.07	—0.2	147,996	192,707	42.4	54.7	75.0	3,488	— 1,942	3.947	584,068	11	59
17	25.0	29.45	+0.2	147,738	191,161	42.3	54.3	74.0	3,495	— 1,546	4.176	617,007	11	66
23	25.5	30.16	0.0	153,326	194,404	43.6	55.2	75.0	3,520	+ 3,243	4.021	616,542	11	60
28	24.4	29.19	—0.3	147,183	191,657	41.8	54.4	73.5	3,517	— 2,747	4.119	606,217	11	62

* Zero is at the same elevation as zero of Lake Providence gauge=89.62 feet above Cairo datum plane, survey Mississippi River.
† These observations were taken in fog and rain with the river full of drift. Meter worked very badly.

Results of discharge observations, Mississippi River, Wilson's Point, Louisiana—Continued.

Date.	Gauges.			Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	No. of velocity stations.	No. of soundings.
				Area.		Depth.			Width.					
	Lake. Providence.	Local.*	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.						
1884.	*Feet.*	*Feet.*	*Feet.*	*Sq. Feet.*	*Sq. Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. Feet.*	*Feet.*	*Cubic Feet.*		
July 7	21.6	26.65	—0.2	135,339	188,454	38.9	53.5	69.5	3,478	— 3,203	4.045	547,467	11	61
22	18.9	24.18	—0.2	133,312	195,043	38.4	55.4	70.0	3,475	+ 6,589	3.936	524,782	11	68
Aug. 14	15.0	20.36	—0.2	115,222	190,388	33.1	54.1	66.0	3,482	— 4,655	3.210	369,906	11	65
Sept. 17	7.2	12.44	—0.4	90,502	193,176	26.1	54.9	58.0	3,467	+ 2,788	2.799	253,330	11	62
Oct. 21	13.9	19.12	+0.2	115,473	194,549	33.5	55.3	67.5	3,444	+ 1,373	3.276	378,308	11	59
Nov. 25	6.8	11.58	0.0	89,647	194,917	26.1	55.4	62.0	3,440	+ 368	2.745	246,115	11	66
1885.														
Jan. 3†	20.5	25.53	+2.3	123,299	180,333	35.5	51.2	72.0	3,478	—14,584	3.880	478,439	12	51
8	27.8	32.91	+1.1	156,648	187,890	44.9	53.4	75.0	3,485	+ 7,557	5.005	784,010	12	57
13	30.6	35.06	+0.2	169,521	193,290	48.8	54.9	79.5	3,502	+ 5,400	5.750	974,761	12	55
21	33.9	37.68	+0.2	174,788	189,363	49.9	53.8	78.5	3,504	— 3,927	5.234	914,925	11	48
26	34.5	38.12	0.0	176,731	189,761	50.4	53.9	79.0	3,504	+ 398	6.327 ‡ 6.696 §	1,118,265 ‡ 1,183,457 §	10 11	68
29	34.6	38.31	0.0	177,942	190,304	50.8	54.1	79.0	3,504	+ 543	5.384	948,073	21	72
Feb. 6	33.8	37.46	—0.5	182,185	197,535	52.0	56.1	79.0	3,505	+ 7,231	5.116	932,134	22	69
14	28.4	32.09	—0.4	157,090	191,292	44.8	54.3	72.0	3,503	— 6,243	4.368	686,192	24	77
19	27.2	31.05	0.0	160,589	198,438	45.9	56.4	71.0	3,502	+ 7,146	4.228	695,079	23	81
25	24.8	28.72	—0.8	150,903	196,918	43.2	55.9	68.0	3,500	— 1,520	4.044	610,245	23	85
Mar. 5	17.6	22.02	+0.1	123,738	192,964	35.7	54.8	62.0	3,469	— 3,954	3.521	435,721	22	97
13	20.9	?25.37	+1.0	138,169	195,845	39.7	55.6	66.0	3,488	+ 2,881	3.968	548,235	22	79
1887.														
Apr. 19	22.8	27.23	—1.3	139,309	191,139	39.3	53.8	60.0	3,545	.....	3.888	541,673	12	40
1888.														
Apr. 22	38.0	41.63	+0.1	179,815	180,526	50.7	50.9	72.0	3,550	.....	6.452	1,160,172	11	34
23	38.1	41.68	+0.1	177,905	178,438	50.1	50.3	71.0	3,550	— 2,088	6.392	1,137,256	11	28
24	38.1	41.63	0.0	174,672	175,383	49.1	49.3	69.0	3,555	— 3,055	6.036	1,051,318	11	29
25	38.1	41.63	0.0	181,421	182,132	51.0	51.2	73.0	3,555	+ 6,749	6.000	1,088,456	11	32
26	38.0	41.56	—0.1	188,075	189,034	53.0	53.2	72.0	3,550	+ 6,902	6.374	1,198,871	11	27
27	37.8	41.43	—0.2	179,252	180,671	50.6	50.8	73.0	3,542	— 8,363	6.250	1,120,357	11	29
1889.														
July 3	29.2	33.03	—0.2	133,739	165,736	36.9	45.5	75.0	3,626	.....	6.388	854,370	11	25
4	28.9	32.70	—0.3	132,462	165,659	36.5	45.4	76.5	3,626	— 77	6.489	859,553	11	26
5	28.3	32.13	—0.6	129,388	164,648	35.7	45.2	76.5	3,624	— 1,011	6.116	791,386	11	25

* Zero is at the same elevation as zero of Lake Providence gauge = 89.62 feet above Cairo datum plane, survey Mississippi River.

† These observations taken under unfavorable circumstances and amid much floating drift. ‡ a.m. § p.m.

Results of discharge observations, Mississippi River, Wilson's Point, Louisiana—Continued.

Date.	Gauges.			Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank, east of section, per second.†	Total discharge of river, per second.	No. of velocity stations.	No. of soundings.
				Area.		Depth.			Width.							
	Lake Providence.	Local.*	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.								
1890.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*		
Jan. 28	34.9	38.73	+0.3	147,690	159,296	39.4	42.5	78	3,744	.....	7.386	1,090,788	.....	1,090,788	10	48
29	35.2	.....	+0.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
30	35.6	.....	+0.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
31	36.1	39.83	+0.5	153,046	160,534	40.9	42.9	79	3,744	+ 1,238	6.971	1,066,966	.....	1,066,966	10	41
Feb. 1	36.4	.....	+0.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
2	36.8	.....	+0.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
3	37.1	40.79	+0.3	153,814	157,707	41.1	42.1	80	3,744	+ 2,827	7.499	1,153,454	.....	1,153,454	10	46
4	37.4	41.03	+0.3	165,766	168,761	44.3	45.1	82	3,744	+11,054	7.029	1,165,164	.....	1,165,164	10	49
5	37.5	41.25	+0.1	159,219	161,391	42.5	43.1	81	3,744	+ 7,370	6.870	1,093,796	5,000	1,098,796	10	52
6	37.8	41.42	+0.3	163,783	165,318	43.7	44.2	82	3,744	+ 3,927	6.847	1,121,471	8,000	1,129,471	10	43
7	38.2	.....	+0.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
8	38.3	41.93	+0.1	171,563	.....	45.8	.....	.....	3,744	.....	6.874	1,179,385	16,000	1,195,385	10	‡42
9	38.4	.....	+0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
10	38.5	42.23	+0.1	178,861	177,363	47.8	47.4	81	3,744	+12,045	6.834	1,222,351	20,000	1,242,351	10	40
11	38.6	42.28	+0.1	175,172	173,487	46.8	46.3	81	3,744	— 3,876	6.696	1,172,882	23,000	1,195,882	10	42
12	38.6	42.27	0.0	173,290	171,643	46.3	45.8	80	3,744	— 1,844	6.403	1,109,604	23,000	1,132,604	10	38
13	38.6	42.28	0.0	174,141	172,456	46.5	46.1	80	3,744	+ 813	6.317	1,100,104	23,000	1,123,104	10	40
14	38.7	42.39	+0.1	177,392	175,295	47.4	46.8	80	3,744	+ 2,839	6.330	1,122,924	25,000	1,147,924	10	41
15	38.7	42.39	0.0	171,602	169,505	45.8	45.3	80	3,744	— 5,790	6.190	1,062,233	25,000	1,087,233	10	41
16	38.7	.....	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
17	38.8	42.45	+0.1	175,514	173,193	46.9	46.3	80	3,744	+ 3,688	6.137	1,077,060	26,000	1,103,060	10	42
18	38.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
19	38.9	.....	+0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
20	39.0	42.78	+0.1	177,728	174,171	47.5	46.5	80	3,744	+ 978	5.982	1,063,254	28,000	1,091,254	10	38
21	39.1	42.83	+0.1	179,984	176,240	48.1	47.1	80	3,744	+ 2,069	6.327	1,138,692	28,000	1,166,692	10	41
22	39.2	42.98	+0.1	182,286	177,980	48.7	47.5	80	3,744	+ 1,740	6,012	1,095,979	29,000	1,124,979	10	42
23	39.3	.....	+0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
24	39.4	43.21	+0.1	178,931	173,764	47.8	46.4	81	3,744	— 4,216	6.221	1,113,174	30,000	1,143,174	10	41
25	39.5	43.27	+0.1	181,393	176,002	48.4	47.0	80	3,744	+ 2,238	6.106	1,107,519	30,000	1,137,519	10	44
26	39.5	43.27	0.0	180.075	174,684	48.1	46.7	80	3,744	— 1,318	5.970	1,075,131	30,000	1,105,131	10	40
27	39.5	43.38	0.0	183,736	177,933	49.1	47.5	80	3,744	+ 3,249	5.786	1,063,172	31,000	1,094,172	10	42
28	39.5	.....	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....

* Zero at same elevation as zero of Lake Providence gauge = 89.62 feet above the Cairo datum plane, survey Mississippi River.
† From field computation, by chief of party.
‡ Interpolated.

Results of discharge observations, Mississippi River, Wilson's Point, Louisiana—Continued.

Date.	Gauges.			Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank, east of section, per second.	Total discharge of river, per second.	No. of velocity stations.	No. of soundings.
	Lake Providence.	Local.*	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.							
				Water.	Below datum.	Mean.	Mean datum.	Maximum.								
1890.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*		
Mar. 1	39.4	43.18	—0.1	179,789	174,735	48.0	46.7	80	3,744	— 3,198	5.801	1,043,044	30,000	1,073,044	10	42
2	39.4	.....	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
3	39.4	43.23	0.0	183,555	178,313	49.0	47.6	80	3,744	+ 3,578	5.911	1,084,915	30,000	1,114,915	10	41
4	39.5	43.31	+0.1	184,903	179,362	49.4	47.9	81	3,744	+ 1,049	5.907	1,092,207	31,000	1,123,207	10	44
5	39.6	43.45	+0.1	185,679	179,614	49.6	48.0	80	3,744	+ 252	5.942	1,103,277	33,000	1,136,277	10	35
6	39.8	43.53	+0.2	190,692	184,327	50.9	49.2	80	3,744	+ 4,713	6.006	1,145,360	34,000	1,179,360	10	42
7	40.0	43.81	+0.2	193,048	185,635	51.6	49.6	81	3,744	+ 1,308	5.814	1,122,367	40,000	1,162,367	10	43
8	40.2	43.93	+0.2	195,692	187,830	52.3	50.2	81	3,744	+ 2,195	5.840	1,142,839	43,000	1,185,839	10	43
9	40.3	.....	+0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
10	40.4	44.26	+0.1	197,730	188,632	52.8	50.4	81	3,744	+ 802	5.973	1,180,951	47,000	1,227,951	10	42
11	40.5	44.30	+0.1	199,068	189,820	53.2	50.7	82	3,744	+ 1,188	6.238	1,241,797	47,000	1,288,797	10	37
12	40.7	44.56	+0.2	202,916	192,695	54.2	51.5	81	3,744	+ 2,875	5.621	1,140,538	50,000	1,190,538	10	43
13	40.9	44.68	+0.2	203,930	193,260	54.5	51.6	81	3,744	+ 565	5.533	1,128,406	50,000	1,178,406	10	42
14	40.9	44.71	0.0	205,205	194,422	54.8	51.9	81	3,744	— 1,162	5.675	1,164,569	50,000	1,214,569	10	42
15	41.0	44.81	+0.1	199,593	188,436	53.3	50.3	82	3,744	— 5,986	5.865	1,170,525	50,000	1,220,525	10	43
16	40.9	.....	—0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
17	40.7	44.73	—0.2	200,443	189,585	53.5	50.6	81	3,744	+ 1,149	5.914	1,185,377	47,000	1,232,377	10	42
18	40.6	44.69	—0.1	199,451	188,743	53.3	50.4	82	3,744	— 842	6.109	1,218,413	45,000	1,263,413	10	43
19	40.4	44.43	—0.2	197,027	187,293	52.6	50.0	81	3,744	— 1,450	6.056	1,193,168	38,000	1,231,168	10	43
20	40.3	44.30	—0.1	199,990	190,742	53.4	50.9	81	3,744	+ 3,449	5.654	1,130,711	35,000	1,165,711	10	43
21	40.2	44.29	—0.1	200,678	191,468	53.6	51.1	80	3,744	— 726	5.433	1,090,294	35,000	1,125,294	10	43
22	40.3	.....	+0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
23	40.2	.....	—0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
24	40.2	44.31	0.0	201,354	192,069	53.8	51.3	80	3,744	— 601	5.824	1,172,684	35,000	1,207,684	10	43
25	40.2	44.33	0.0	200,431	191,071	53.5	51.0	80	3,744	— 998	6.082	1,218,946	35,000	1,253,946	10	43
26	40.2	.....	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
27	40.0	.....	—0.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....
28	39.9	44.05	—0.1	199,361	191,049	53.2	51.0	79	3,744	— 22	5.947	1,185,677	30,000	1,215,677	10	42
29	39.8	.....	—0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	42
30	39.6	.....	—0.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	42
31	39.6	43.58	0.0	196,146	189,594	52.4	50.6	78	3,744	— 1,455	5.982	1,173,386	25,000	1,198,386	10	42
Apr. 1	39.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	42
2	39.5	43.55	—0.1	195,601	189,161	52.2	50.5	78	3,744	— 433	5.489	1,144,165	23,000	1,167,165	10	42
3	39.6	43.68	+0.1	195,887	188,961	52.3	50.5	79	3,744	— 200	6.034	1,182,027	23,000	1,205,027	10	42
4	39.4	43.43	—0.2	195,501	190,511	52.5	50.9	78	3,744	+ 1,550	5.979	1,174,924	21,500	1,196,424	10	42
5	39.3	43.28	—0.1	195,828	190,399	52.3	50.9	79	3,744	— 112	3,732	1,122,393	20,000	1,142,393	10	42
6	39.3	.....	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	42

	7	39.3	43.28	0.0	195,314	189,885	52.2	50.7	78	3,744	— 514	5.776	1,128,112	19,000	1,147,112	10	42
	8	39.3	43.28	0.0	195,719	190,290	52.3	50.8	78	3,744	+ 405	5.701	1,115,742	18,000	1,133,742	10	42
	9	39.3	43.28	0.0	196,042	190,613	52.4	50.9	78	3,744	+ 323	5.622	1,102,056	17,000	1,119,056	10	42
	10	39.3	43.23	0.0	192,041	186,799	51.3	49.9	78	3,744	— 3,814	5.728	1,099,945	16,000	1,115,945	10	42
	11	39.3	43.23	0.0	191,808	186,566	51.2	49.8	77	3,744	— 233	5.712	1,095,566	15,000	1,110,566	10	42
	12	39.3	43.23	0.0	193,538	188,296	51.7	50.3	78	3,744	+ 1,730	5.909	1,143,563	15,000	1,158,563	11	41
	13	39.3	.....	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	42
	14	39.3	43.23	0.0	192,974	187,732	51.5	50.1	77	3,744	— 564	5.588	1,078,298	15,000	1,093,298	11	42
	15	39.2	43.13	—0.1	194,324	189,457	51.9	50.6	77	3,744	+ 1,725	5,604	1,088,952	14,000	1,102,952	11	42
	16	39.3	.....	+0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	42
	17	39.3	43.13	0.0	194,305	189,438	51.9	50.6	78	3,744	— 19	5.513	1,071,221	14,000	1,085,221	11	42
	18	39.2	43.08	—0.1	194,147	189,467	51.9	50.6	77	3,744	+ 29	5.566	1,080,699	13,000	1,093,669	11	42
	19	39.3	43.01	+0.1	195,489	191,071	52.2	51.0	77	3,744	+ 1,604	5.523	1,079,777	12,000	1,091,777	11	42
	20	39.3	.....	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	42
	21	39.3	43.05	0.0	191,652	187,084	51.2	50.0	77	3,744	— 3,987	5.701	1,092,657	12,000	1,104,657	11	42
	22	39.3	43.04	0.0	192,149	187,619	51.3	50.1	77	3,744	+ 535	5.603	1,076,696	12,000	1,088,696	11	42
	23	39.3	.....	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	42
	24	39.4	43.08	+0.1	194,273	189,593	51.9	50.6	77	3,744	+ 1,974	5.736	1,114,351	12,000	1,126,351	11	42
	25	39.3	43.01	—0.1	194,199	189,781	51.9	50.7	76	3,744	+ 188	5.628	1,092,930	11,000	1,103,930	11	42
	26	39.1	42.78	—0.2	195,909	192,252	52.3	51.4	77	3.744	+ 2,571	5.563	1,089,843	9,000	1,098,843	11	42
	27	38.9	.....	—0.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	42
	28	38.7	42.33	—0.2	189,429	187,557	50.6	50.1	75	3,744	— 4,795	5.479	1,037,800	5,000	1,042,800	11	42
	29	38.5	42.13	—0.2	189,457	188,334	50.6	50.3	76	3,744	+ 777	5.431	1,028,916	0	1,028,916	11	42
	30	38.4	42.01	—0.1	186,693	186,019	49.6	49.7	75	3,744	— 2,315	5.524	1,031,336	0	1,031,336	11	42
May	1	38.3	.....	—0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	42
	2	38.2	41.81	—0.1	185,774	185,849	49.6	49.6	75	3,744	— 170	5.501	1,021,930	0	1,021,930	10	42
	3	38.1	.....	—0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	4	38.1	.....	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	5	38.0	41.73	—0.1	189,393	189,767	50.6	50.7	75	3,744	+ 3,918	5.372	1,017,338	0	1,017,338	10	43
	6	37.9	41.58	—0.1	189,918	199,854	50.7	51.0	73	3,744	+ 1,087	5.344	1,014,895	0	1,014,895	10	42
	7	37.9	41.48	0.0	189,628	190,938	50.6	51.0	.....	3,744	+ 84	5.172	980,701	0	980,701	10	(?)23

* Zero at same elevation as zero of Lake Providence gauge = 89.62 feet above the Cairo datum plane, survey Mississippi River.

NOTE.—Velocities were observed with Price current meters, Nos. 4 and 5, at six-tenths depth from the surface as mean velocity at each velocity station.

Results of discharge observations at break in Skipwith Levee, Mississippi.

Date.	Gauges.			Cross-section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Method.
				Area.		Depth.			Width.				
	Lake Providence.	Wilson's Point discharge section.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1890.	*Feet.*	*Feet.*	*Feet.*	*Square feet.*	*Square feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Square feet.*	*Feet.*	*Cubic feet.*	
Apr. 2	39.5	43.55	−0.1	34,118	.....	33.4	.....	52	1,020	.....	1.867	63,704	Meter at surface.*
5	39.3	43.28	−0.1	39,525	.....	35.9	.....	50	1,100	.....	2.097	82,870	Meter 0.6 of depth from surface.
9	39.3	43.28	0.0	39,684	.....	32.8	.....	51	1,210	.....	1.877	74,480	
14	39.3	43.23	0.0	40,424	.....	32.6	.....	51	1,240	.....	1.920	77,648	
16	39.3	43.13	+0.1	41,875	.....	33.8	.....	50	1,240	.....	1.772	74,188	
19	39.3	43.01	+0.1	41,014	.....	33.1	.....	48	1,240	.....	1.548	63,477	
24	39.4	43.08	+0.1	42,508	.....	33.7	.....	46	1,260	.....	1.669	70,954	
28	38.7	42.33	−0.2	42,210	.....	33.5	.....	48	1,260	.....	1.521	64,210	
May 1	38.3	41.91	−0.1	39,970	.....	31.7	.....	51	1,260	.....	1.063	42,487	
6	37.9	41.58	−0.1	38,728	.....	30.7	.....	45	1,260	.....	0.996	38,566	

* Four-fifths of surface velocity is taken as mean velocity at velocity stations.

NOTES.—The break is 529 miles below Cairo and near Skipwith, Miss. The measurements were taken on a section in line with the ends of the broken levee. There is a small excess of computed discharge, since the direction of the flow was not perpendicular to the section.

Zeros of both gauges are 89.62 feet above Cairo datum plane, survey Mississippi River.

REPORT OF CAPTAIN CHARLES F. POWELL, CORPS OF ENGINEERS, IN CHARGE OF SURVEY OF THE MISSISSIPPI RIVER.

MISSISSIPPI RIVER COMMISSION,
OFFICE OF THE SECRETARY,
St. Louis, Mo., June 5, 1890.

The field work of topography and hydrography was resumed in early August, 1889, at next above Chester, Ill., and carried to Alton, Ill., by the end of November, when the work was stopped for the year, making 94 miles of main river and 22 miles of old river and tributaries. A report of operations by Mr. C. M. Winchell, chief of party, is attached.

The topographic and hydrographic field work is now continued from Donaldsonville, La. The triangulation, reduced, still ends at Keokuk, Iowa, and the precise levels, also reduced, at Fulton, Ill., 179 and 350 miles, respectively, above Alton.

Of the mapping, the manuscript detail sheets were finished to Chester, and about one-quarter of the twenty-six sheets from Chester to Alton completed; four of 7-inch-mile manuscript sheets, Cairo to Alton, were partly drawn, and the ten new-edition sheets of the same scale, below Cairo, were completed; the preparation of the manuscript detail sheets for reduction and publication as sixty-nine charts, scale 20,000, Donaldsonville to near Commerce, Mo., which work was in hand at date of last report, was completed, and the last material forwarded to the printer some time ago; the material of six sheets out of seventeen, from Commerce to Alton, was partly prepared.

Of the published charts, editions of thirty-six numbers of the 20,000-scale series were completed, leaving fifteen from Donaldsonville to Commerce to be printed, which should be all done by August. The work of photolithographing and printing the ten new edition inch-mile charts was awarded in succession to the lowest three bidders; the first two failed after reasonable trial to furnish the required quality of work and the job was withdrawn from them. Chart No. 1 is now printed, although the edition is not yet received; and work has been begun on four other sheets.

The gauge records of the river and tributaries, except the Missouri for 1887 and 1888 and 1889, were published in two volumes of stages, etc. The reductions to the present engineer gauges of gauge readings preceding 1880 at Cairo, Vicksburgh, and Natchez were carefully revised by a study of all the notes of the connections at times of gauge shiftings or re-establishments. It was found from the records that the Natchez readings before 1860, as published in the report for 1889, were generally a few tenths too large, and that the highest reading, that for 1862, was 49.9 instead of 50.3; also that the Vicksburg high-water readings before the same year were each 2 feet too large, and that the published 1862 reading of 51.2 was somewhat doubtful, one authority placing it less than 49.3 and one connection at 49.1. At Natchez there is one link of the reduction of the Delta-survey gauges not verified. Search was made for data and some found for reducing the Delta-survey gauges to present gauges at Columbus, Lake Providence, and Red River Landing, but the results are not considered reliable and are therefore not quoted.

Captain Willard, in charge of water-gauges on the Mississippi, has obtained the old Delta note-books, and has kindly undertaken to go over the whole matter, have search made from the old benches, and new levels run to the present gauges. It is expected to subsequently publish, when the matters are definitely settled as far as possible, a new table of the highest and lowest yearly gauge readings at the different stations, correcting at the same time some typographical errors in the table of last report.

After the conclusion of late New Madrid discharge observations, for which a party and instruments were sent from here at request of the first district engineer, this party leveled from the New Madrid gauge to the precise benches at Tiptonville for checking the reduction of that gauge zero to the datum. The 1890 high-water slope around the bend at this locality was also determined by the party. The plot of the adopted high-water grade line of 1889 appeared anomalous at New Madrid, and it was desired to clear up the matter. A small change resulted from the leveling in the elevation of the gauge zero, and the point of change of slope in the actual high-water line was found to be a few miles below the gauge; otherwise the irregularities noticed in the plotted grade line proved to be apparent only, and the good explanation for them remaining is the circumstance of high banks along the bend, and the fact that the river, as in no other place in its whole length, flows north, or directly against its flood plane for 10 miles, thereby elevating the water for increased head, and giving more slope when resuming the direction of the flood plane.

The tide gauge records at Biloxi, Miss., was reduced, tabulated, and plotted; they were also examined in connection with the Signal-Service observations of wind, atmospheric pressure, and rain at New Orleans, Port Eads, and Mobile with the result that wind especially and atmosphere have had appreciable effects on the observed elevations of the water surface, but that it is impracticable to measure by the record

their variations from the mean effect of these elements. It appears that the arithmetical mean of the monthly mean gauge readings will give the best value, from the observations, of mean Gulf level; this mean is about 0.3 of a foot less than the provisionally adopted value. Since the monthly means are rather discordant, it is desirable by multiplying the observations to use those for nearly one year whose consideration had been omitted on account of an irregularity in their record. An effort is to be made to discover the amounts of the irregularity and therefore the proper corrections.

A volume was published during the year of data of permanent points of the river survey and gauge bench-marks below Cairo whose elevations have been determined for convenient use in the field and to better secure reductions in local surveys and levelings to the general survey datum; several copies of the volume have been furnished the district officers and levee engineers. A compilation is being made from all notes and reports of locations, descriptions, and elevations of flood marks or benches, more particularly for use in leveling to later flood marks, a great many of which were made of the late high water, and whose descriptions have been kindly furnished by numerous volunteer observers or agents detailed by the district and levee engineers.

Of the more permanent *personnel* on the river survey, Mr. C. W. Clark has continued as principal assistant in the drawing division, and Messrs. J. A. Ockerson and C. M. Winchell have been connected with the topographical part. Messrs. Wood, Maltby, Connet, and French, topographers, left the work for more lucrative or permanent employment elsewhere. Mr. Dunaway, formerly rodman and recorder, but retained in the office topographical division, and Messrs. Field and Ritter, levelers, also left; it is expected that the latter will return in time for the next field season.

The survey fleet, consisting of the steamer *Patrol* and two survey boats, belonging on the Commission property return, and a steam-launch, are laid up in Alton Slough. The pieces are in good condition and ready for service.

By having a steamer with the survey party last season the work was made to progress up-stream and to be continuous; short and frequent moves of the survey boats were permitted, thus materially saving time in going to and from the daily work. Two moves were made last season without the aid of the *Patrol*, as it was necessary to dock her and make repairs below the water-line. A careful comparison of actual cost of field work by having the steamer with the survey boats and not shows a small decrease for the former; another advantage is more room for drawing, etc., when in the field.

The balance of funds on hand increased by $75,000 will permit, it is estimated, (1) the publication of maps to Alton; (2) extension of precise levels to Duluth, including reduction; (3) publications of maps for 125 miles beyond Alton, including needed field work therefor; and (4) triangulation and its reduction for 50 miles. There is call for the levels from the upper-river improvement work, and when they are run to St. Paul it would be desirable to make a connection, as a closing check, with the mean level of Lake Superior, and thereby with mean tide near New York.

There is no special need in the interests of navigation of the survey beyond St. Paul. The cost of completing the work to that point and publishing the maps in addition to the funds in hand and also in addition to $75,000, the expected appropriation for the coming year, is nearly $225,000; the field work could readily be completed inside of three years with but little addition to the present survey plant, which has only been used for several years to about one-half its capacity during a single season. The provision of the full amount, even if accompanied by annual limit of expenditure of one-third, would much conduce to economy and to the value of the results for the immediate future by preventing a detrimental prolongation of the work. Surveying as a preliminary or accompaniment of navigation improvement work, or as a record of the condition at one period of a changeable water—even one as little changeable as the Upper Mississippi—should for every reason be made with the least practicable delay and in the least practicable time.

Besides the continuance of the survey, there is urgent need, it appears to me, of a hydrographic, low-water survey of the alluvial river. About one-eighth only of the present survey below Cairo was made at low water. The period of field work was from 1857 to 1884; a part, however, having been done since 1870, another part since 1876, and the greater part since 1880. The triangulation, precise levels, and stone-lines are still generally available for new work of topography and hydrography. The estimate of cost, lately submitted, with explanations of this limited resurvey, is $212,526. The work can advantageously be done in four years.

As desired, I have also estimated upon the annual cost of needed local surveys, examinations, investigations, etc., on the lower river, and find the amount to be nearly $45,000; so that in round numbers $175,000 result as the estimated amount which can be profitably expended in the fiscal year 1892 for continuing the survey to St. Paul, and for the hydrographic resurvey, and examinations, investigations, etc., on the

alluvial river. It is suggested that continuing the survey and the resurvey of the alluvial river might well be consolidated in one appropriation item.

Respectfully submitted.

CHAS. F. POWELL,
Captain, Corps of Engineers.

The PRESIDENT OF THE MISSISSIPPI RIVER COMMISSION.

Money statement.

July 1, 1889, amount available		$48,832.95
July 1, 1890, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1889	$44,952.79	
July 1, 1890, outstanding liabilities	1,858.16	
	46,810.95	
July 1, 1890, balance available		2,022.00
Amount (estimated) required for completion of existing project to St. Paul		300,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		175,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

List of civilian engineers employed during the year to May 31, 1890, *on work of river and harbor improvement in charge of Capt. Charles F. Powell, Corps of Engineers, and under the river and harbor appropriation act of August* 11, 1888.

Name and place of residence.	Time employed.		Compensation per month.	Where employed.	Work on which employed.
	Months.	*Days.*			
J. A. Ockerson, St. Louis, Mo	4	.....	$200	St. Louis	Survey of Mississippi River.
C. M. Winchell, St. Louis, Mo	11	18	175	In field and at St. Louis.	Do.
Kivas Tully, St. Louis, Mo	10	.....	175	St. Louis	Do.
C. W. Clark, St. Louis, Mo	8	.....	175	St. Louis	Do.
B. H. Colby, St. Louis, Mo	.....	7	135	St. Louis	Do.
E. L. Harman, St. Louis, Mo	.....	27	130	New Madrid, Mo	Do.
H. W. Baker, St. Louis, Mo	12	.....	175	Madison, Ind., and St. Louis.	General service, improving Mississippi River below the mouth of the Ohio.

REPORT OF ASSISTANT ENGINEER C. M. WINCHELL, CHIEF OF SURVEY PARTY.

ST. LOUIS, MO., *April* 23, 1890.

CAPTAIN: I have the honor to submit the following report on the operations of the field party under my direction during the season of 1889, with a statement of some results of the field measurements of 1888 and some observations upon the river from Cairo to Alton:

In obedience to your instructions the party assembled at St. Louis on August 2, and were conveyed by steamer to Chester, Ill., where the survey boats *Illinois* and *Kentucky*, steam-launch No. 5, and United States steamer *Patrol* were in waiting to receive us.

The organization of the party was the same as in former years: Messrs. F. B. Maltby, G. W. Wood, E. J. Jolley, O. W. Connet, G. H. French, and W. G. Comber, were topographers; J. H. Field and L. E. Ritter, levelers; E. L. Harmon and G. W. Wisner, hydrographers; and G. Bischoff, computer and plotter. The total number of men in the party, including crew of the *Patrol* and galley force, averaged about sixty.

The survey of the river was resumed, where the work of the season before ended, at stone-line 31, in Kaskaskia Cut-off, and at St. Mary's, Mo., in Old River. When the

field season closed in December, 1888, permanent and easily-accessible marks were established both for elevation and position. These were found undisturbed, and the survey continued from them up-stream without any delay on August 3. Having the *Patrol* with the party during the season was a great improvement over former seasons, giving us better quarters and more room both for office work and for sleeping that the quarter-boats alone furnished, and I think also it is more economical to have the *Patrol* with the party to move the boats whenever it is advantageous to move, rather than to depend on outside aid to move from camp to camp. We occupied 20 different camps between Chester and Alton, the moves averaging 5.3 miles each.

The entire season was favorable for survey work both as to stage of river and weather. The river remained at a low stage with only slight fluctuations; from August 3 to November 30 there were only five days when it rained all day, and seven other days that were partly lost on account of showers. On November 30 the survey was completed to Alton, Ill., and work closed on stone-line 61, which passes through Mo. R. C. △ Alton and just above head of Ellis Island.

As in 1888, permanent marks were left at the end of the work whose elevations are known, and the azimuths of lines connecting them determined. December 1 the boats were laid up in the Alton Slough, behind Ellis Island, and the party disbanded.

The survey is based on a system of secondary triangulation done by the Mississippi River Commission in 1880. At the time this triangulation was done, territory points were located on or near the river bank every 3 or 4 miles for the purpose of checking a later topographic survey, but so many of these points were caved into the river, or otherwise destroyed, that it was found necessary to carry a system of tertiary triangulation over the entire reach of river surveyed.

This tertiary triangulation was checked by connection with secondary lines or triangulation stations and by chaining bases every few miles.

TOPOGRAPHY.

Two stadia lines were run along each bank, checking on the tertiary triangulation stations. From these main stadia lines other lines were run back into the country to develop the topographic features and contours. These side lines generally made a circuit, returning to the river and checking on a main-line stake or sounding flag.

On the left bank the country is level, and mostly cultivated, and a strip bordering the river of an average width of 1½ miles was surveyed. From St. Louis to Ste. Genevieve the river follows the bluffs on the right bank. These bluffs are precipitous on their river face, very irregular, being cut up by deep gullies and ravines in all directions. These ravines are full of a growth of small timber and brush and the ridges range from 150 to 400 feet in height above the river. On account of these features it required fully twice as much time and labor to survey the right bank as it did the left. A strip averaging but little more than half a mile in width was surveyed on the right bank.

At Ste. Genevieve the river leaves the bluffs on the Missouri side, crosses the valley, and comes to the foot of the bluffs in Illinois at Kaskaskia near the head of Kaskaskia Cut-off. This Cut-off was caused by the Mississippi caving into the Okaw River in 1881, when it left its old bed via St. Mary's, Mo., and took the channel of the Okaw to Illinois penitentiary at Chester, where it again joins its original channel; this Cut-off is 8½ miles long and shortens the river 7 miles, it being 15½ miles around the old channel. The Cut-off has changed from a sluggish narrow stream 75 meters wide to a rapid river averaging more than 200 meters in width. Its maximum width is over 300 meters, and the narrowest place is where it strikes the rocky bluff near its head and makes a sharp turn (about 90 degrees to the south. Here it is only 170 meters wide and is a difficult piece of river to navigate. The old river by St. Mary's is gradually filling up, and is now navigable only at medium to high stages of river.

If the present rate of caving at head of Kaskaskia Island continues it will not be many years before the site of the old town of Kaskaskia will be wiped out of existence. From Kaskaskia the river hugs the Illinois bluffs to Rockwood, about 17 miles. Here it again crosses to the Missouri bluffs at Grand Eddy, and there follows along their base to Cape Girardeau, 44 miles. Immediately below Cape Girardeau is an opening in the bluffs about 4 miles wide, where the first overflow water from the Upper Mississippi enters the head of the St. Francis basin through Niggerwool Swamp.

At Gray's Point the Illinois bluffs approach to within about 1,000 meters of the Missouri bluffs, and from here to Commerce, 7 miles, the river flows over a rocky bed with high bluffs on either side. At Santa Fé the Illinois bluffs trend SE. to the Ohio River.

The Commerce Bluff is a large detached rocky hill, the main line of bluffs leaving the river in a SW. direction at Cape Girardeau.

The last natural rock found in the river above Cairo is Beaver Dam Rock, about 1½ miles below Commerce, nearly in the main river channel. This rock appears to be a

huge boulder, and at a low-water stage of the river projects more than 3 feet out of the water, and is a constant menace to passing steam-boats.

About 4 miles above Grand Tower, on the east side of the river, is a detached rock hill called Fountain Bluff. This bluff is about 9 miles in circumference and 450 feet high. The west side is very steep; the north side has a rock precipice over 100 feet high, while the east and south sides have a more gradual slope. It is 4 miles west of the main line of bluffs in Illinois.

The highest bluff near the river is Buck Knob, just below Crystal City, which is 488 feet high.

From Alton to Kaskaskia, 87 miles, the bluffs on the east side are from 3 to 10 miles from the river, the widest part of the bottom being opposite and above St. Louis. This entire line of bluff was located and connected with the river; these bluffs have a more gradual slope than the Missouri bluffs, and are not so badly cut up by ravines.

The Okaw was surveyed to where it comes out of the hills, also about 5 miles of the Meremec River, as well as several lakes and streams between the Illinois bluffs and the Mississippi. All the railroad tracks centering in East St. Louis were located across the bottom to where they enter the hills.

From the mouth of the Missouri River to Crystal City, 55 miles, the general course of the river is a little west of south. From Crystal City to Fountain Bluff, 65 miles, it runs southeast. Here it turns more towards the south and only makes about 19 miles of easting from here to Cairo, 84 miles.

Many points, both triangulation and bench-marks, of the survey made by Major Simpson, 1870–1878, were found and connected with, so that changes in the bank-lines since then can be noted by comparing the two surveys; several township and section corners were connected with, as well as four county lines and the stone marking St. Louis City limits. Connection was made with five U. S. Coast and Geodetic Survey triangulation stations on the bluffs east of St. Louis, including their American Bottom base stations. By comparison of M. R. C. with U. S. Coast and Geodetic Survey positions, as determined astronomically, it was found that they differed 134.4 meters in latitude and 33.4 in longitude, the M. R. C. positions being farther south and west. Two of the Missouri River Commission triangulation stations were connected with, also two of their stone-line bench-marks near mouth of Missouri River.

LEVELS.

All elevations are referred to the Memphis datum and are checked by connection with Mississippi River Commission precise level bench-marks.

A continuous line of levels was run along each bank, and once in about 3 miles of river a stone line was established. The levels were duplicated on all stone lines; thirty-one stone lines were established between Chester and Alton. A river crossing of levels was made at each stone line to check the levels on the side of river where there were no P. B. M's. All triangulation stations, permanent marks of other surveys, boundary stones, etc., were touched on and will be tabulated and described in the table of "Permanent marks above Cairo." All water-gauges were connected with and the water-surface at each cross-section determined.

Two U. S. Coast and Geodetic Survey bench-marks on the Eads Bridge were leveled to. Their difference of elevation by our ordinary level river crossing is .001 foot. The Coast Survey published difference is .003 foot. Our ordinary level value of Missouri River Commission bench-mark at mouth of Missouri River differs from their determination of it by 2 feet.

The experience of the last two seasons' survey proves that many of the stone posts used for marking stones, both bench-marks and triangulation stations, have been disturbed. Some are taken by natives and reset for land corners, and used for sills or door-steps, others are broken up by fishermen and used for sinking nets, and several were found cracked and broken in pieces, apparently by fire. It would seem, therefore, that all marks intended to be permanent should be buried beneath the surface or cut on the natural rock with sufficient surface marks so that they can be easily found and identified.

HYDROGRAPHY.

Cross-sections were sounded about every 350 meters and longitudinal along the channel. These soundings were taken from a six-oared yawl-boat and were located by two observers with sextants. In all there were 31,624 casts of the lead between Chester and Alton, and 10,201 double-sextant angles. The deepest water found above Cairo was 112 feet, opposite Grand Tower. The shoal reaches are where the river is wide and dotted with sand-bars and islands, the water being dispersed through several channels. The depth at Kaskaskia Cut-off ranges from 20 to 40 feet; at its mouth it was 70 feet deep. The Okaw at same stage is from 10 to 15 feet deep.

The greatest changes in bank line since Major Simpson's survey, except at Kaskaskia Cut-off, are in Salt Lake Bend. Here the bend has moved east and south about a mile.

The bank is also caving quite rapidly at the lower end of Greenleaf Bend, at Commercial Point, Liberty Bar, and in Sawyer Bend above St. Louis.

Appended are tables showing surface slope of river, discrepancies in levels, and results of tertiary triangulation.

Very respectfully, your obedient servant,

C. M. WINCHELL,
Assistant Engineer.

Capt. CHAS. F. POWELL,
Corps of Engineers.

River slope during survey, being at about low water.

Locality.	Distance.	Slope per mile.	Locality.	Distance.	Slope per mile.
	Miles.	*Feet.*		*Miles.*	*Feet.*
Foot of Kaskaskia Chute to Head Fairy Island	11.0	0.75	Chesley Island to Cliff Cave	6.9	0.68
Head Fairy Island to Mud Landing	5.6	0.67	Cliff Cave to Docks	5.3	0.42
Mud Landing to Bruce Island	6.5	0.64	Docks to foot of Dorcas street	4,9	0.35
Bruce Island to Penitentiary Point	5.3	0.34	Dorcas street to Brooklyn street	4.3	0.34
Penitentiary Point to Durfee Point	5.9	0.64	Brooklyn street to Carrie avenue	3.5	0.59
Durfee Point to Cornice Rock	4.9	0.73	Carrie avenue to near Annie avenue	3.2	1.05
Cornice Rock to Herculaneum	4.3	0.52	Annie avenue to head of Chouteau Island	4.5	0.87
Herculaneum to Glen Park	4.0	0.53	Chouteau Island to near Wood River	5.5	0.30
Glen Park to Chesley Island	4.2	0.41	Wood River to Alton	4.6	0.39

Discrepancies between right and left bank ordinary levels.

Field season.	Distance.	Locality where compared.	Difference.	Field season.	Distance.	Locality where compared.	Difference.
1888.	4	Elkins Landing	0.060	1889.	3	Ames Island	0.022
	3	Blackbird Island	0.168		2½	Perry Tow-head	0.008
	3½	Saladin Tow-head	0.105		3½	Below Calico Bar	0.029
	3	Thompson's Landing	0.061		2½	Head of Calico Bar	0.142
	4	Scudder Tow-head	0.137		4	Illinois Station	0.036
	3	Dickey Island	0.044		3	Head of Foster Island	0.105
	3½	Fountain Bluff	0.036		3	Montesano Springs	0.152
	3	Estelle's Landing	0.152		3	Foot of Widow Beard's Island	0.050
	3¼	76 Landing	0.139		3½	Twin Hollows	0.029
	3	Wilkinson's Landing	0.074		3	Above Quarantine	0.029
	3	Price Landing	0.036		3½	Above Vulcan Iron Works	0.156
	3	Liberty Island	0.001		3	Head of Arsenal Island	0.006
	3	Foot of Crain's Island	0.046		3	L'Esperance street	0.197
	4	Cole's Mill	0.084		2	Eads Bridge	0.035
1889.	10	Head of Kaskaskia Cut-off	0.164		3	Merchants' Bridge	0.086
	1	Foot of Moro Island	0.133		1½	Foot of Gabaret Island	0.012
	4½	Head of Moro Island	0.115		3½	Head of Gabaret Island	0.015
	3	Above Little Rock Landing	0.134		4½	Head of Chouteau Island	0.031
	3	Head of Turkey Island	0.045		4½	Above mouth of Missouri River	0.007
	3	Bruce Island	0.025		6	Alton	0.005
	3	Brickey's Mill	0.137				
	3	Rush Island	0.133				

Discrepancies between precise and ordinary levels.

Field season.	Between P. B. M's.	Distance.	Discrepancies.	Observer.	Field season.	Between P. B. M's.	Distance.	Discrepancies.	Observer.
		Miles.					*Miles.*		
1888.	No. 64 and 65	21	—0.150	L. E. Ritter.	1889.	No. 25 and 23	8½	—0.086	J. H. Field.
	No. 45 and 44	3	+0.040	J. H. Field.		No. 23 and 22	2	—0.033	Do.
	No. 44 and 42	9	—0.107	Do.		No. 22 and 20	4	—0.055	Do.
	No. 42 and 41	7½	+0.018	Do.		No. 20 and 18	8	—0.093	Do.
	No. 41 and 39	6	+0.027	Do.		No. 18 and 17	2	+0.002	Do.
1889.	No. 38 and 35	7	+0.200	Do.		No. 17 and 16	2½	+0.132	Do.
	No. 35 and 34	11½	+0.002	Do.		No. 16 and 15	5	+0.006	Do.
	No. 34 and 33	3	—0.015	Do.		No. 15 and 14	3	+0.216	Do.
	No. 32 and 31	2½	—0.038	Do.		No. 14 and 12	9½	+0.085	Do.
	No. 31 and 30	4	+0.172	Do.		No. 12 and 11	4	—0.006	L. E. Ritter.
	No. 30 and 29	3	—0.031	Do.		No. 11 and 10	2	—0.029	Do.
	No. 29 and 27	10	—0.177	Do.		No. 10 and 8	4½	—0.194	Do.
	No. 27 and 25	6	.....	Do.					

The sum of these discrepancies is —0.058 foot for a distance of 102 miles.

Comparison of tertiary triangulation with chained sides.

1889.

Sides compared.	No. of triangles.	Tertiary lengths.	Measured lengths.	Discrepancies.
		Meters.		
△ 19–△ 21	20	1,243.8	1,242.6	1 in 1,036
△ 35–△ 37	19	1,250.6	1,249.1	1 in 834
△ 47–△ 49	15	1,298.7	1,296.7	1 in 649
△ 65–△ 67	22	1,375.5	1,376.6	1 in 1,251
△ 91–△ 93	28	1,235.69	1,235.64	1 in 24,713
△ 107–△ 109	17	1,313.9	1,312.8	1 in 1,194
△ 139–△ 141	45	1,118.6	1,118.9	1 in 3,729
△ Alton-Church Spire	29	1,341.7	*1,341.8	1 in 13,418

*Secondary triangulation length.

REPORT OF CAPTAIN CHARLES F. POWELL, CORPS OF ENGINEERS, IN CHARGE OF GENERAL SERVICE.

ST. LOUIS, MO., *June* 8, 1890.

The movement of stone to the first and second districts, in progress at the end of last year, May 31, 1889, was completed during June and July; there were then delivered at—

Daniel's Point	yards..	8,499
Plum Point	do....	2,025
Helena	do....	8,208
Cairo (for Hickman)	do....	399
Total		19,131

All requisitions on the general service for stone having been filled, the towage fleet was laid up at Cairo.

The delivery of stone for the season, which had been commenced in March, was made with a small number of barges, and one tow-boat at one time, except that the *Mississippi* in returning from a Commission inspection trip brought up some empty barges. The stone was unloaded on the bank, except the last tow, by the district force and about as delivered. As the stage of water was very generally lower than average high water, the unloading was probably more costly than would ordinarily be during spring and early summer.

During the working season considerable repair was made to five barges, as they were in an unsafe condition, and new pillow-blocks and a boiler sheet were put on the tow-boat *Etheridge*.

As there appeared no probability of more call for stone, the fleets in the late fall were moved to Paducah for winter quarters, where they remain, except some barges left in the districts.

The twenty stone barges whose building was under contract at date of last report were completed; ten additional barges of the same kind were also built by the contractors for the general service upon purchase in open market. One old barge, 192, was rebuilt, by hired labor, from the bottom up; another old barge was cut down to the bottom gunwale with a view of rebuilding; old barge, 144, was lost while in service in the third district, and two old barges are in use for carrying houses of Commission survey boats. All this leaves thirty-one good stone barges, six good open-hold (fuel) barges, and forty-six old stone barges generally in poor condition, available for towage use after some repairs are made to the latter.

The tow-boat *Minnetonka* was hauled out, her bottom thoroughly repaired, and afterwards much repair made above the water-line. New cylinder timbers were put on the steamer *Vidette*, together with other new or repaired work; new cylinders are now being made for her, one cylinder having become wholly disabled and the other being weak. Some chalking, painting, and miscellaneous repairs or changes were made in the pieces of the fleet generally, being in the aggregate rather extensive.

The tow-boat *Etheridge*, belonging on the third district property return, but which has been with the general service for a few years, was called for by Captain Young during the flood and delivered to him at Memphis. The *Minnetonka* and *Mississippi*, also the Commission steamer *Patrol* and three barges, were kept in readiness for use at short notice during the flood.

The cost of maintaining and caring for the towage fleet during long periods of suspension of its work has been duly considered. With the view of arriving at some action in the matter, a searching inquiry has been made as to the actual cost of the general service stone and coal towage. The time before 1883 was a period of preparation and plant building, when not much stone towage was done, and its cost is complicated with that of the other work. The expenditure during the seven years ending December 31, 1889, was therefore taken as the bases for finding the unit cost; the amount was corrected by the unpaid obligations, the actual cost of each piece of service performed other than coal and stone towage, and by the value of plant on hand at the end of the period; then, considering the numbers of yard-miles of stone moved and equivalent of same of coal, the actual gross cost of 6.2 mills per yard-mile was obtained. During the 7-year period operations were conducted for thirty-eight months and suspended for forty-six months.

A similar method to that above was taken for finding the cost for each of the last two towage seasons, one being from October to December, 1888, a low-water season, and the other from March to July, 1889, a season of low high water, and the actual costs obtained, considering all expense of operation and current repairs, of 2.8 and 2.4 mills per yard-mile respectively, which show approximately the relative values of high and low-water towage; this, after allowing 13 cents per yard for the extra handling of the stone in high-water delivery, makes the cost of delivery of stone at Helena about equal for high and low water, and greater for low water for points below, and as much as 7 cents per yard greater for Wilson Point. Ii should be remarked that low-water stone delivery requires much more plant of the expensive kind and necessitates the risk of not supplying the stone as fast as needed dur.ng construction.

It is expected to subsequently submit the matter of the stone towage to the Commission with some recommendations in the premises.

Respectfully submitted,

CHAS. F. POWELL,
Captain, Corps of Engineers.

To the PRESIDENT OF THE MISSISSIPPI RIVER COMMISSION.

Approximate value of plant belonging to the United States and used in the general service, improving the Mississippi River from the Head of the Passes to the mouth of the Ohio River.

Class of property.	No.	Approximate value May 31, 1890.	Class of property.	No.	Approximate value May 31, 1890.
Steam-boat Mississippi	1	$45,000.00	Store-boat	1	$450.00
Steam-boat Minnetonka	1	30,000.00	Skiffs	7	100.00
Steam-boat Vidette	1	4,750.00	Sounding-boats	2	25.00
Barges, flush-deck, new	30	83,180.61	Calking-flat	1	20.00
Barges, flush-deck	24	22,100.00	Office furniture	....	475.00
Barges, low-deck	27	29,160.00			
Barges, open-hold	6	10,000.00	Total		225,260.61

Abstract of formal contracts in force.

No.	Name and address of contractor.	Contract.	
		Date.	Subject.
1	Madison Marine Railway Company, Madison, Ind.; per C. A. Korbly, secretary.	February 9, 1889	Building and delivering at Cairo, Ill., twenty wooden barges. Supplementary contract made extending time of completion twenty-five days. Contract completed.

Money statements, July 1, 1889, to June 30, 1890.

General service:

Available July 1, 1889		$161,334.83
Refunded account payment for Hickman		3,288.83
Refunded account payment for Columbus		2,599.08
Refunded account payment for Helena		10,393.17
		177,615.91
Transferred to protection of levees, third district		20,000.00
		157,615.91
Expenditures apportioned to first district	$34,843.98	
Expenditures apportioned to Hickman	269.32	
Expenditures apportioned to second district	34,843.99	
Expenditures apportioned to Helena	10,393.17	
Expenditures apportioned to third district	34,844.00	
		115,194.46
In Treasury	39,978.82	
In hand	2,442.63	42,421.45

Illinois River to Ohio River, protection of the easterly bank of the Mississippi near Cairo:*

Available July 1, 1889		8,600.00
First district—Plum Point Reach:		
Available July 1, 1889	254,944.10	
Applied by general service	34,843.98	
Deposit for overpayment	1.00	
Transferred from levees, Plum Point Reach	4,000.00	
		293,789.08
Transferred to protection of levees, second district	2,500.00	
Transferred to protection of levees, fourth district	21,000.00	
		23,500.00
		290,289.08
Expended		258,123.86
In Treasury	5,086.85	
In hand	7,078.37	
		12,155.22

Hickman, Kentucky:

Available July 1, 1889	77,882.78	
Applied by general service	269.32	
		78,152.10
Refunded to general service	3,288.83	
Expended	26,215.51	29,504.34
In Treasury	47,461.17	
In hand	1,186.59	
		48,647.76

* Includes only funds under act of July 5, 1884.

Columbus, Kentucky:		
Available July 1, 1889		$33,478.21
Refunded to general service	$2,599.08	
Expended	17,862.97	20,462.05
In Treasury	6,150.72	
In hand	6,865.24	
		13,016.16
Maintenance of existing works:		
Available July 1, 1889		27,250.00
Transferred to protection of levees, third district		27,250.00
Gauges:		
Available July 1, 1889		1,651.50
Expended		720.00
In Treasury	900.00	
In hand	31.50	
		931.50
Observations and discharges:		
Available July 1, 1889		370.92
Expended		370.92
Surveys, examinations, and inspections:		
Available July 1, 1889		2,744.91
Expended		903.46
In Treasury	1,000.00	
In hand	841.45	
		1,841.45
Care of plant first and second districts:		
Available July 1, 1889		60,000.00
Expended		39,547.85
In Treasury	14,000.00	
In hand	6,452.15	
		20,452.15
Surveys first and second districts:		
Available July 1, 1889		1,815.80
Expended		560.50
In Treasury	1,000.00	
In hand	255.30	
		1,255.30
Second district—Memphis Reach:		
Available July 1, 1889	37,523.06	
Applied by general service	34,843.99	
	72,367.05	
Transferred to protection of levees, fourth district	20,000.00	52,367.05
Expended		36,188.38
In Treasury	13,500.00	
In hand	2,678.67	
		16,178.67
Memphis Harbor:		
Available July 1, 1889		14,833.75
Expended		9,214.01
In Treasury	4,750.00	
In hand	869.74	
		5,619.74

Helena:		
Available July 1, 1889	$71,174.09	
Applied by general service	10,393.17	
		$81,567.26
Refunded to general service	10,393.17	
Expended	71,171.29	
		81,564.46
In hand		2.80
Gauges:		
Available July 1, 1889		792.50
Expended		510.00
In Treasury	100.00	
In hand	182.50	
		282.50
Observations and discharges:		
Available July 1, 1889		522.07
Expended		520.00
In hand		2.07
Surveys, examinations, and inspections:		
Available July 1, 1889		2,913.96
Expended		1,338.90
In Treasury	1,000.00	
In hand	575.06	
		1,575.06
Third district—Lake Providence Reach:		
Available July 1, 1889	455,566.84	
Applied by general service	34,844.00	
		490,410.84
Transferred to protection of levees, third district	55,000.00	
Transferred to protection of levees, fourth district	20,000.00	
Transferred to protection of levees, Tensas Front, fourth district	25,000.00	
		100,000.00
		380,410.84
Expended		383,884.18
In hand		6,526.66
Vicksburg Harbor:		
Available July 1, 1889	101,098.49	
Deposit for overpayment	.25	
		101,098.74
Expended		63,792.99
In Treasury	*15,000.00	
In hand	22,305.75	
		37,305.75
Vicksburg Harbor—Delta Point:		
Available July 1, 1889		156.58
Expended		0.00
In hand		156.58
Greenville, Mississippi:		
Available July 1, 1889		33,204.13
Expended		29,721.65
In hand		3,482.48

*This amount is reserved for such repairs and extension of the Delta Point revetment as may prove to be necessary.

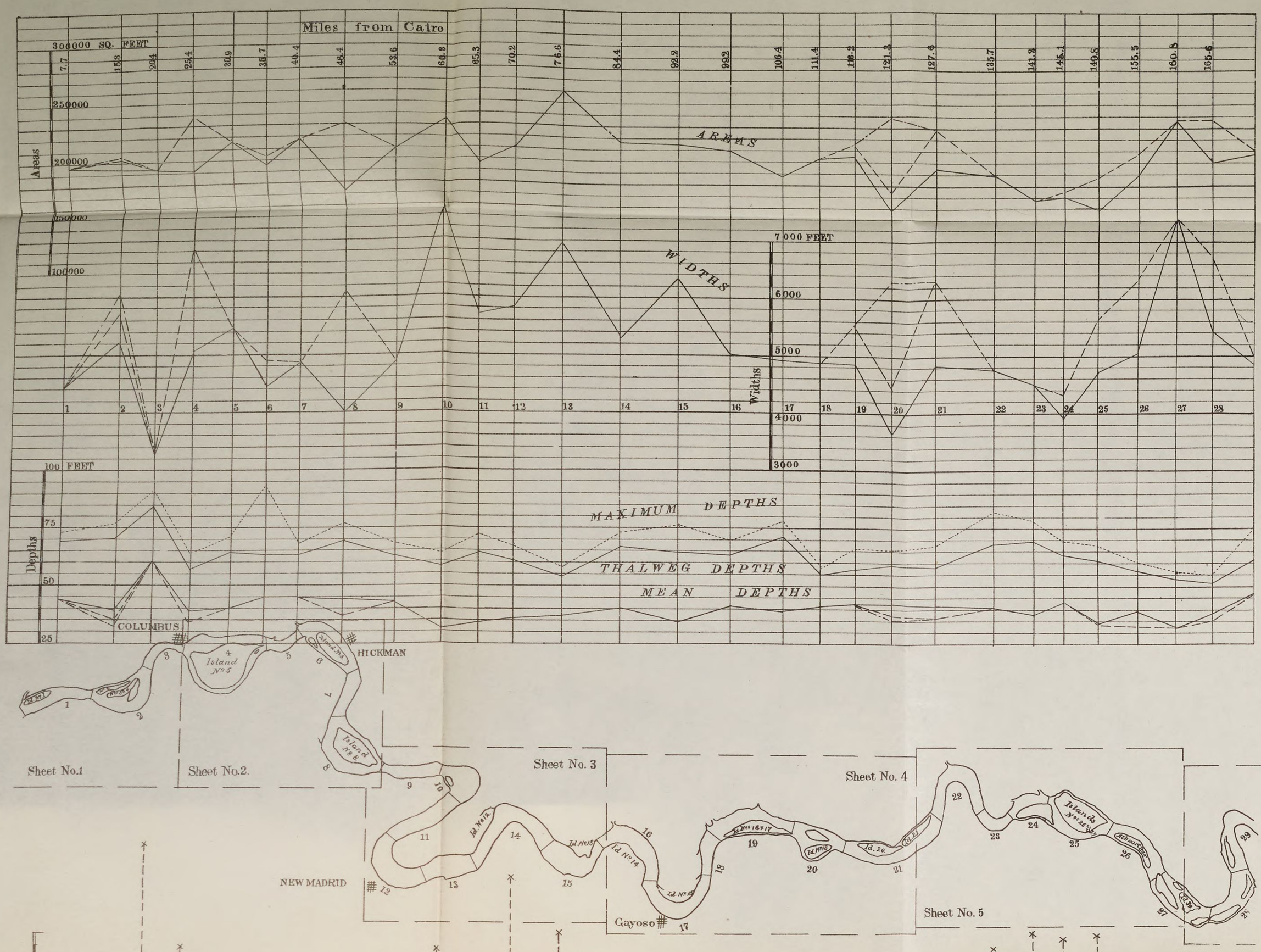
Lake Bolivar Front:		
Available July 1, 1889		$46,605.52
Transferred to surveys, examinations, and inspections, third district	$4,000.00	
Transferred to surveys, examinations, and inspections, fourth district	3,000.00	
Transferred to protection of levees, fourth district	3,000.00	
Transferred to protection of levees, third district	5,000.00	
		15,000.00
		31,605.52
Expended		11,315.80
In Treasury	20,000.00	
In hand	289.72	
		20,289.72
Gauges:		
Available July 1, 1889		1,229.65
Expended		730.75
In Treasury	300.00	
In hand	198.90	
		498.90
Observations and discharges:		
Available July 1, 1889		82.38
Expended		82.38
Surveys, examinations, and inspections:		
Available July 1, 1889	1,970.63	
Transferred from levees, second Mississippi district	1,535.68	
Transferred from levees, Ben Lomond Hoop	613.78	
Transferred from levees, Lake Bolivar Front	4,000.00	
		8,120.09
Expended		7,057.83
In hand		62.26
Fourth district—New Orleans Harbor:		
Available July 1, 1889	127,041.62	
Deposit for overpayment	.04	
		127,041.66
Expended		78,522.04
In Treasury	45,000.00	
In hand	3,519.62	
		48,519.62
Red and Atchafalaya rivers:		
Available July 1, 1889	88,560.13	
Deposit for overpayment	.10	
		88,560.23
Expended		64,828.60
In Treasury	15,000.00	
In hand	8,731.63	
		23,731.63
Natchez and Vidalia:		
Available July 1, 1889		700.65
Expended		25.00
In hand		675.65

Gauges:		
Available July 1, 1889		$1,125.22
Expended		725.20
In hand		400.02
Observations and discharges:		
Available July 1, 1889		2,460.41
Expended		2,460.41
Surveys, examinations, and inspections:		
Available July 1, 1889	$594.44	
Transferred from Lake Bolivar Front	3,000.00	
		3,594.44
Expended		2,087.03
In hand		1,507.41
Levees (first district):		
Plum Point:		
Available July 1, 1889		19,894.60
Transferred to protection of levees, fourth district	15,000.00	
Transferred to Plum Point Reach	4,000.00	
		19,000.00
		894.60
Expended		818.63
In hand		75.97
Survey of St. Francis Front:		
Available July 1, 1889		471.83
Expended		471.83
Levees (second district):		
White River Front:		
Available July 1, 1889		3,954.35
In Treasury	2,500.00	
In hand	1,454.35	
		3,954.35
First Mississippi district:		
Available July 1, 1889		7,677.84
Expended		7,167.76
In hand		510.08
Protection of levees:		
Available July 1, 1889	5,000.00	
Transferred from Plum Point Reach	2,500.00	
		7,500.00
Expended		1,595.55
In Treasury	5,000.00	
In hand	904.45	
		5,904.45
Levees (third district):		
Tensas Front (Ark.):		
Available July 1, 1889		1,936.46
Expended		1,936.46
Yazoo Front, Ben Lomond Hoop:		
Available July 1, 1889		613.78
Transferred to surveys, examinations, and inspections		613.78

Second Mississippi district:		
Available July 1, 1889		$1,649.32
Expended	$113.64	
Transferred to surveys, examinations, and inspections	1,535.68	
		1,649.32
Protection of levees:		
Available July 1, 1889	23,701.57	
Transferred from general service	20,000.00	
Transferred from Lake Providence Reach	55,000.00	
Transferred from maintenance of existing works	27,250.00	
Transferred from Lake Bolivar Front	5,000.00	
Deposit for overpayment	3.00	
		130,954.57
Expended		130,207.14
In hand		747.43
Levees (fourth district):		
Tensas Front:		
Available July 1, 1889	87,199.14	
Transferred to protection of levees, fourth district	10,000.00	
		77,199.14
Expended		48,081.72
In hand		29,117.42
Protection of levees, Tensas Front:		
Available July 1, 1889	9,371.77	
Transferred from protection of levees, fourth district	10,000.00	
		19,371.77
Expended		19,371.77
Protection of levees:		
Available July 1, 1889	10,000.00	
Transferred to protection of levees, Tensas Front	10,000.00	
Transferred from Memphis Reach	20,000.00	
Transferred from Lake Providence Reach	45,000.00	
Transferred from levees, Tensas front, fourth district	10,000.00	
Transferred from levees, Plum Point Reach	15,000.00	
Transferred from Plum Point Reach	21,000.00	
Transferred from Lake Bolivar Front	3,000.00	
		114,000.00
Expended		95,839.87
In hand		18,160.13
Levees, total:		
Available July 1, 1889		171,470.66
Transferred to surveys, examinations, and inspections, Third district	2,149.46	
Transferred to Plum Point Reach	4,000.00	
		6,149.46
		165,321.20
Transferred from Lake Providence Reach		100,000.00
Transferred from general service		20,000.00
Transferred from Memphis Reach		20,000.00
Transferred from Plum Point Reach		23,500.00
Transferred from maintenance of existing works		27,250.00
Transferred from Lake Bolivar Front		8,000.00
Deposit for overpayment		3.00
		364,074.20
Expended		305,604.37
In Treasury	7,500.00	
In hand	50,969.83	
		58,469.83

PLATE I.

REGIMEN OF THE MISSISSIPPI RIVER



Eng 90

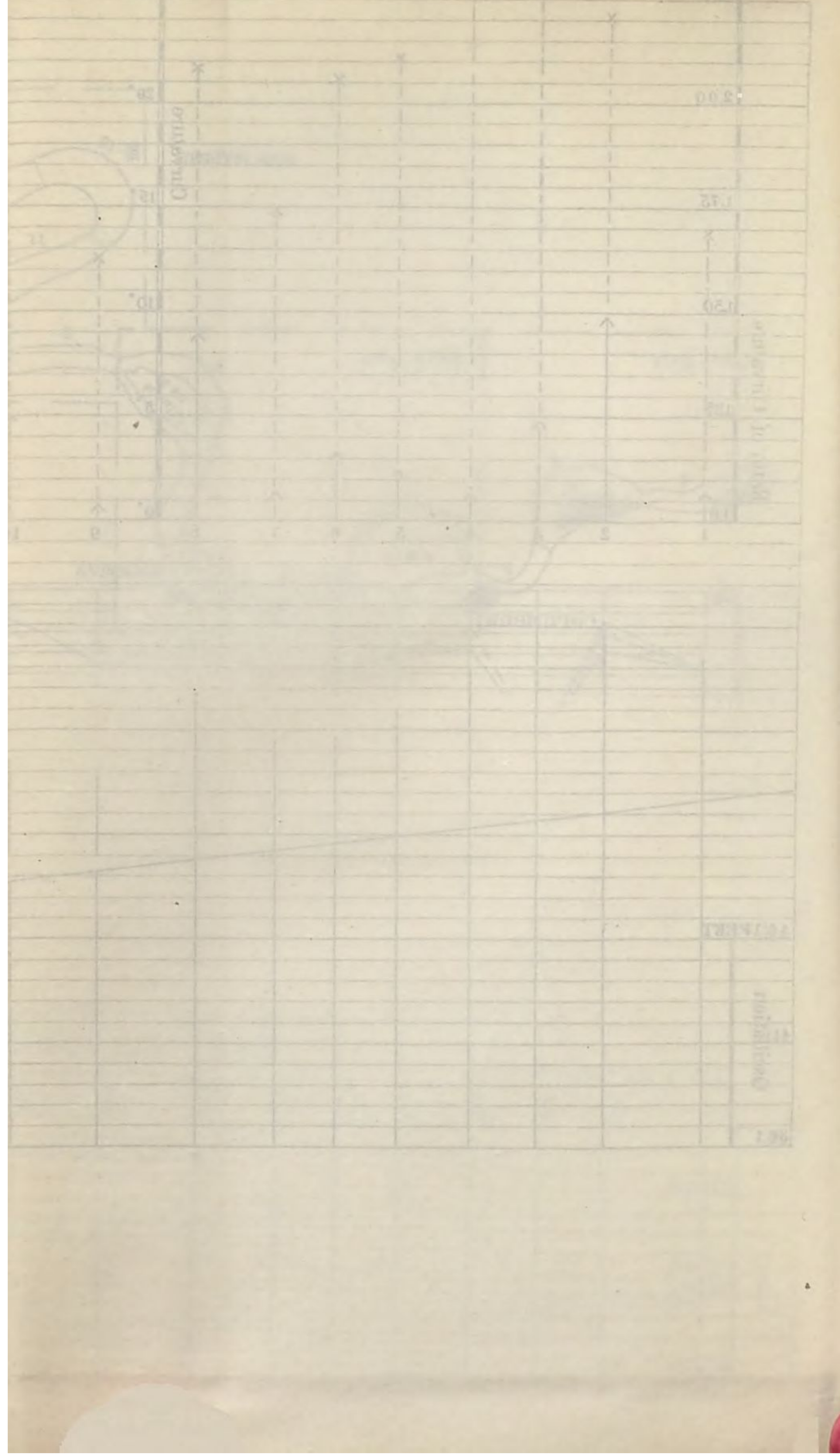


PLATE II.

REGIMEN OF THE MISSISSIPPI RIVER.

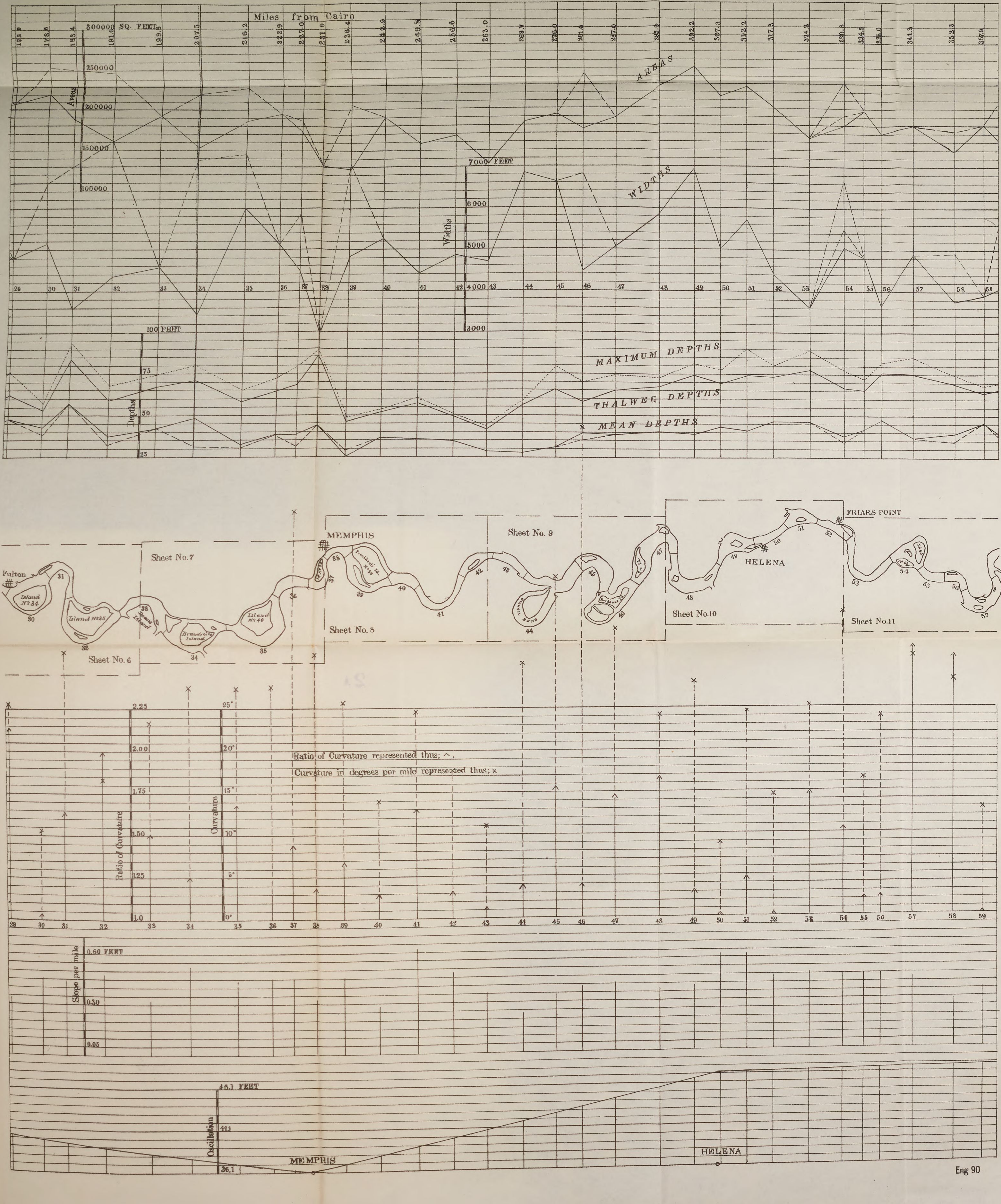
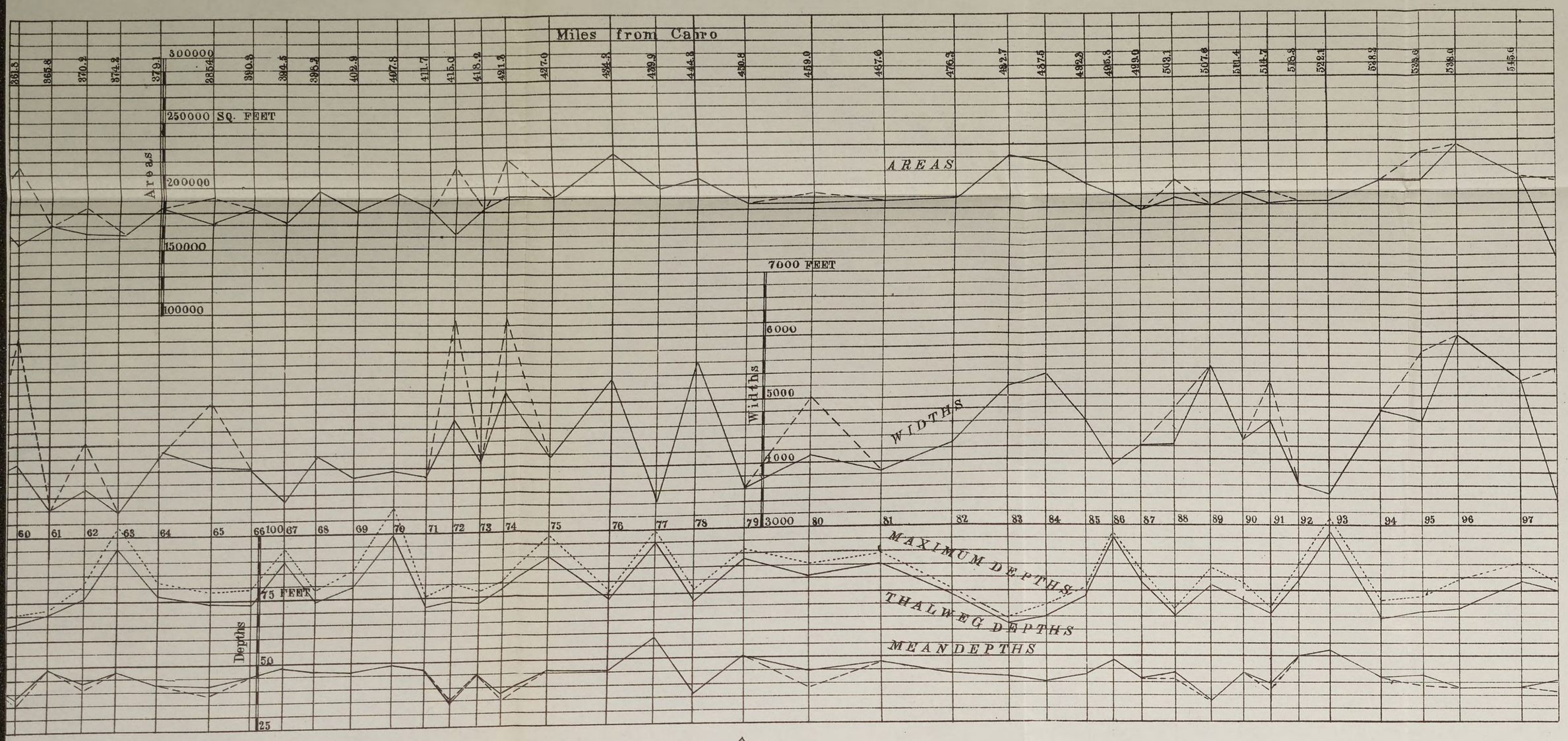
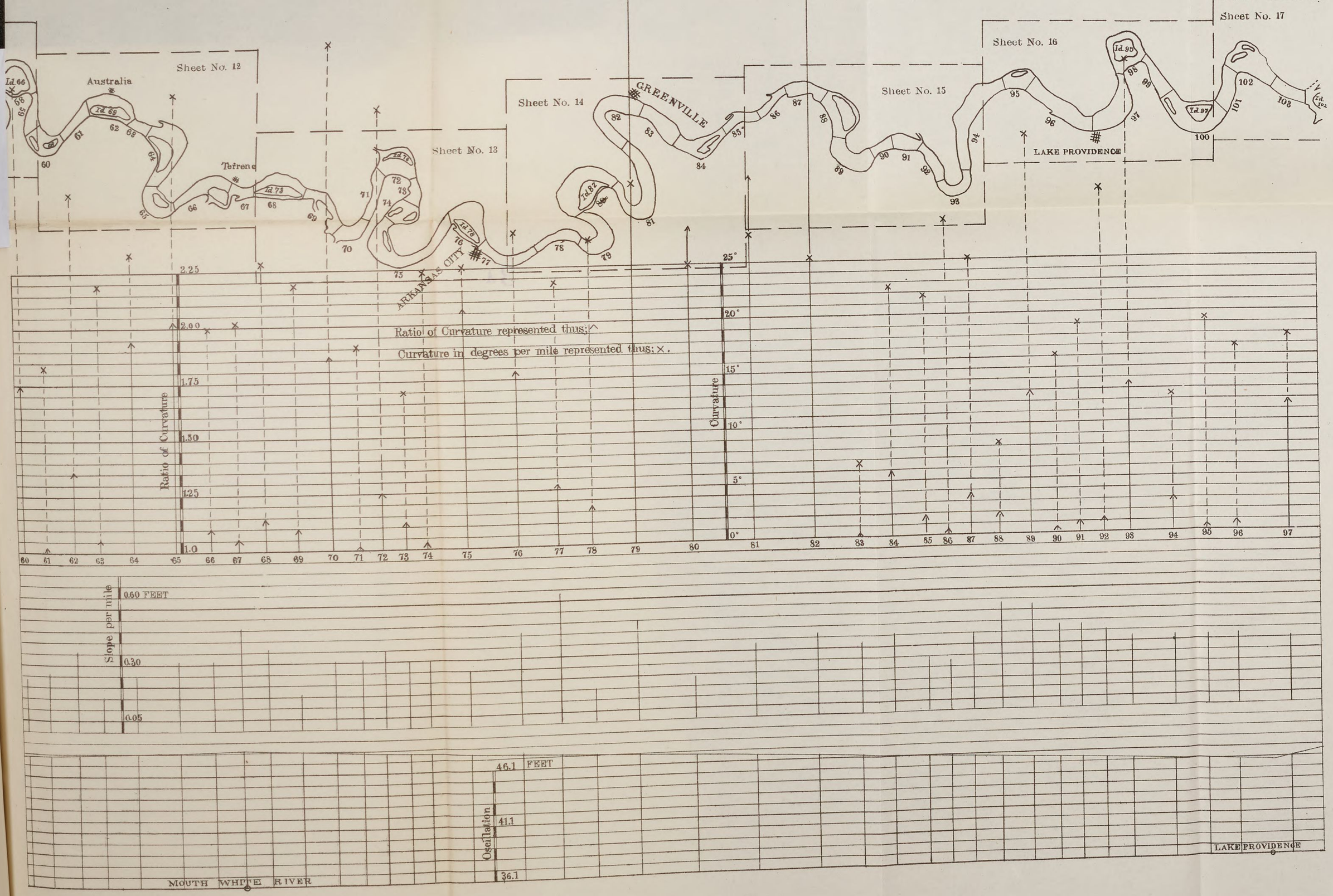


PLATE III.

REGIMEN OF THE MISSISSIPPI RIVER





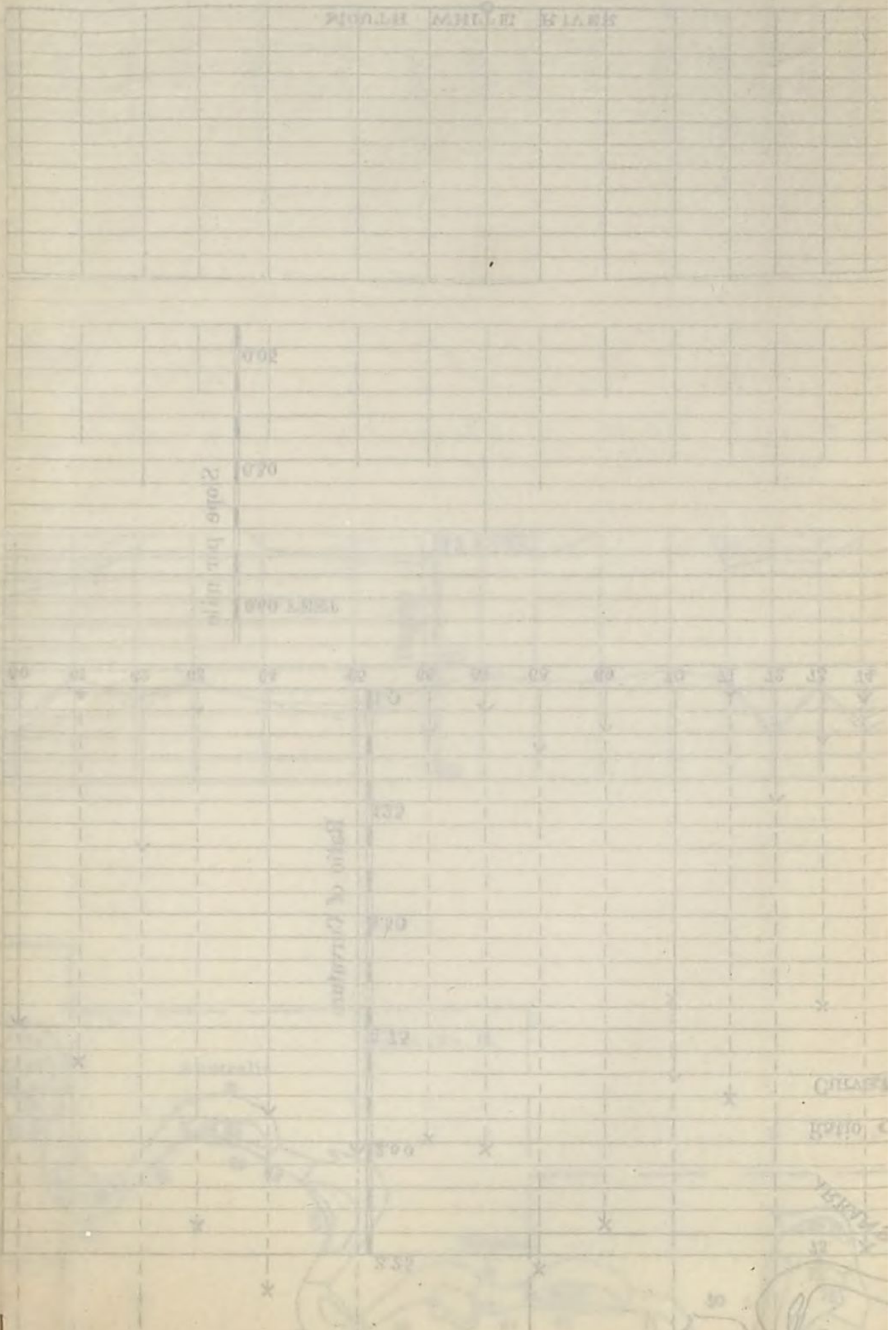


PLATE IV.

REGIMEN OF THE MISSISSIPPI RIVER

Miles from Cairo

AREAS

250000 SQ. FEET

200000

150000

100000

Areas

WIDTHS

7000 FEET

6000

5000

4000

3000

Widths

MAXIMUM DEPTHS

THALWEG DEPTHS

MEAN DEPTHS

100 FEET

75

50

25

Depths

VICKSBURG

NATCHEZ

Sheet No. 17

Sheet No. 18

Sheet No. 19

Sheet No. 20

Sheet No. 21

Sheet No. 22

Ratio of Curvature

2.25

2.00

1.75

1.50

1.25

1.0

Curvature

25

20°

15°

10°

5°

0°

Ratio of Curvature represented thus; ^.

Curvature in degrees per mile represented thus; x

Slope per mile

0.60 FEET

0.30

0.05

Oscillation

46.1 FEET

41.1

36.1

VICKSBURG

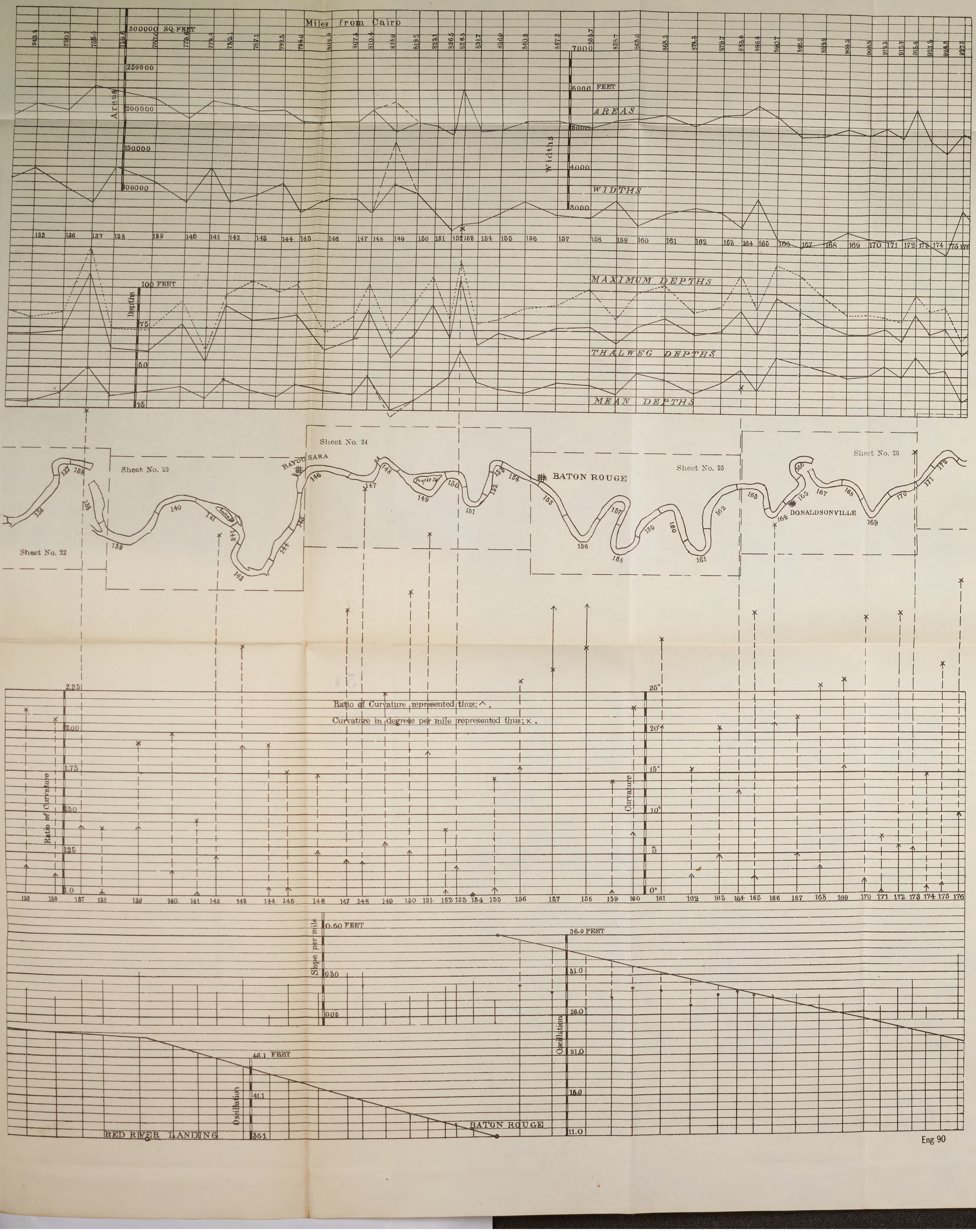
NATCHEZ

98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134

Eng 90

PLATE V.

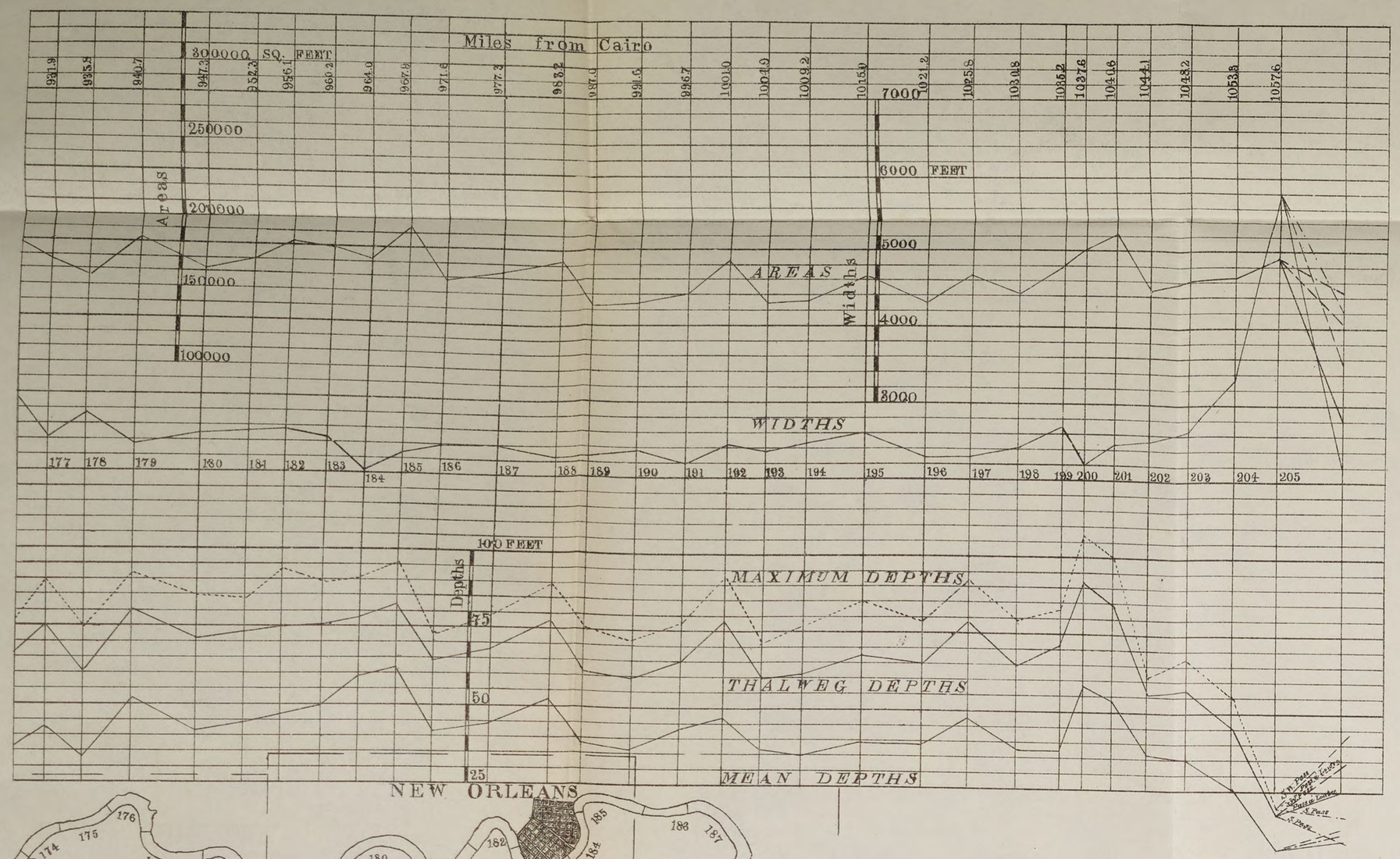
REGIMEN OF THE MISSISSIPPI RIVER

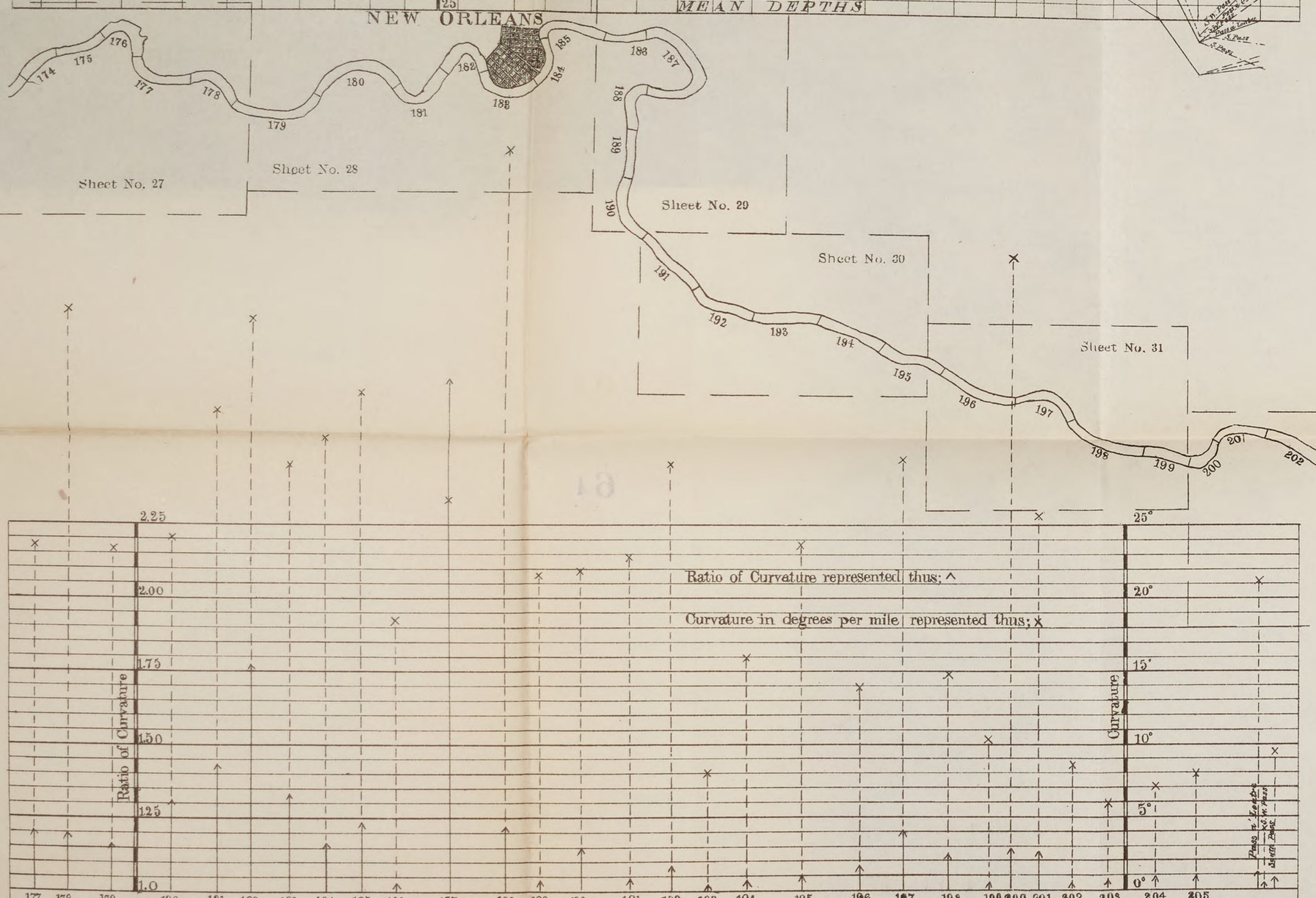


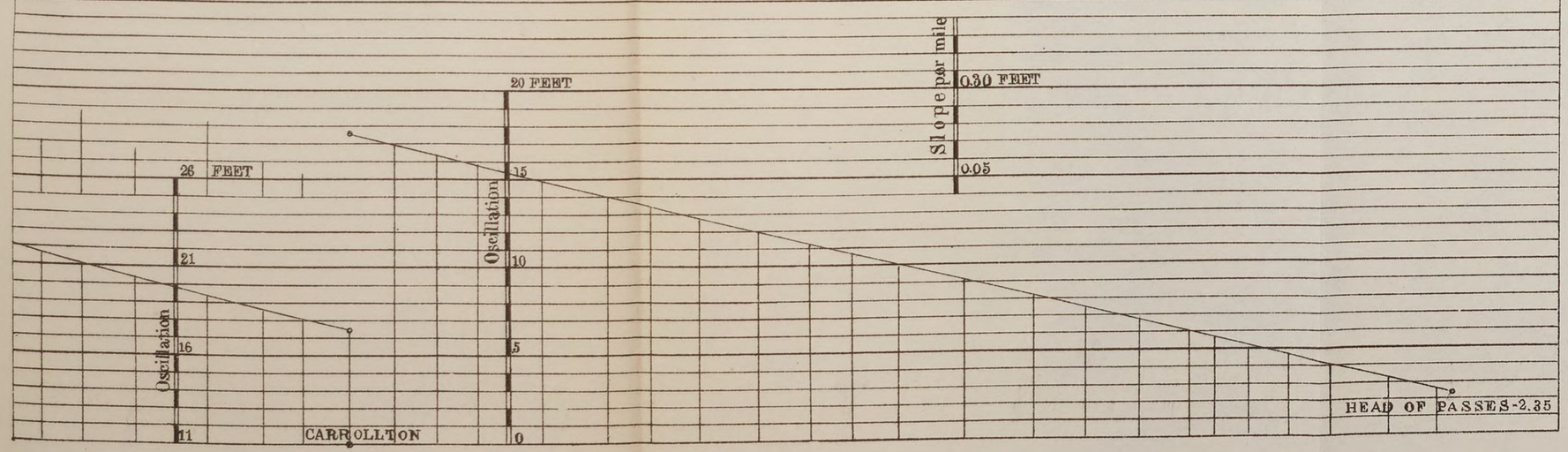
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PLATE VI

REGIMEN OF THE MISSISSIPPI RIVER







Consolidated statement, March 3, 1881, *to June* 30, 1890.

Act of March 3, 1881		$1,000,000.00
Act of August 2, 1882		4,123,000.00
Act of January 19, 1884		1,000,000.00
Act of July 5, 1884, less $5,000 transferred to snag-boat service		2,065,000.00
Act of August 5, 1886, less $5,942.60 for expenses, office Chief of Engineers		1,994,057.40
Act of August 11, 1888, less $4,289 for expenses, office Chief of Engineers		2,840,711.00
Total specific appropriations		13,022,768.40
Balances from former appropriations applied to works below Cairo under act of August 2, 1882, less $123.42 reverted to Treasury	$272,504.96	
Same for work above Cairo, under act of July 5, 1884	22,632.53	
Total balances		295,137.49
Received from sales, loss of property, and deposits		675.88
Total available		13,318,581.77
Expended to June 30, 1890:		
River works	$9,759,217.89	
Levees	3,183,745.54	
		12,942,963.43
Balance July 1, 1890		375,618.34

Detailed statement, March 3, 1881, to June 30, 1890.

Districts.	Balances.	Appropriations and allotments.	Applied by general service.	From sales, etc.	Total available.	Expended.	In Treasury.	In hand.	Total balances.
Des Moines Rapids to Illinois River	$12,663.38	$195,000.00		$145.14	$207,808.52	$207,808.52			
Illinois River to Ohio River	9,969.15	470,000.00		126.60	480,095.75	480,095.75			
Protection near Cairo		50,000.00		10.85	50,010.85	41,410.85		$8,600.00	$8,600.00
Total	9,969.15	520,000.00		137.45	530,106.60	521,506.60		8,600.00	8,600.00
Survey St. Francis Front		9,873.11			9,873.11	9,873.11			
New Madrid Reach		200,721.86	$9,640.05	2.83	210,364.74	210,364.74			
Plum Point Reach		2,735,321.18	285,448.95	106.70	3,020,876.83	3,008,711.61	$5,086.85	7,078.37	12,165.22
Hickman, Ky		85,461.17	3,288.83		88,750.00	40,102.24	47,461.17	1,186.59	48,647.76
Columbus, Ky		41,150.92	2,599.08		43,750.00	30,733.84	6,150.92	6,865.24	13,016.16
Gauges		2,500.00			2,000.00	1,068.50	900.00	31.50	931.50
Observations and discharges		3,000.00			3,000.00	3,000.00			
Surveys, examinations, and inspections		3,000.00			3,000.00	1,158.55	1,000.00	841.45	1,841.45
Levees, Plum Point		156,000.00			156,000.00	155,924.03		75.97	75.97
Total First District		3,236,528.24	300,976.91	109.53	3,537,614.68	3,460,936.62	60,598.94	16,079.12	76,678.06
Survey, St. Francis Front		4,000.00			4,000.00	4,000.00			
Helena Reach		8,000.00			8,000.00	8,000.00			
Levees, Long Lake		15,000.00			15,000.00	15,000.00			
Yazoo Front		140,950.00			140,950.00	140,950.00			
White River Front		75,000.00			75,000.00	71,045.65	2,500.00	1,454.35	3,954.35
First Mississippi district		50,000.00			50,000.00	49,489.92		510.08	510.08
Yazoo, Miss., Delta		100,000.00			100,000.00	100,000.00			
Protection of levees		7,500.00			7,500.00	.1,595.55	5,000.00	904.45	5,904.45
Memphis Harbor		256,750.00		22.80	256,772.80	251,153.06	4,750.00	869.74	5,619.74
Reach		160,000.00	50,821.51		210,821.51	194,642.84	13,500.90	2,678.67	16,178.67
Harbor and reach		431,792.38	138,282.94	27.14	570,052.46	570,052.46			
Helena		64,606.83	10,393.17		75,000.00	74,997.20		2.80	2.80
Gauges		1,000.00			1,000.00	717.50	100.00	182.50	282.50
Observations and discharges		3,000.00			3,000.00	2,997.93		2.07	2.07
Surveys, examinations, and inspections		3,000.00			3,000.00	1,424.94	1,000.00	575.06	1,575.06
Total second district		1,320 599.21	199,447.62	49.94	1 520,096.77	1,486,067.05	26,850.00	7,179.72	34,029.72
Care of plant, first and second districts		85,005.99			85,005.99	64,553.84	14,000.00	6,452.15	20,452.15
Surveys, first and second districts		10,000.00			10,000.00	8,744.70	1,000.00	255.30	1,255.30

Survey Vicksburg Harbor		2,500.00			2,500.00	2,500.00			
Unleveed fronts		1,000.00			1,000.00	1,000.00			
Choctaw Reach		2,679.86			2,679.86	2,679.86			
Levees, Opossum Fork		120,000.00			120,000.00	120,000.00			
Yazoo Front		364,878.95			364,878.95	364,878.95			
Yazoo Front (Ben Lomond)		11,386.22			11,385.22	11,386.22			
Yazoo Front (Hughes Break)		6,849.69			6,849.69	6,849.69			
Tensas Front		566,723.00			566,723.00	566,723.00			
Tensas Front, Arkansas		179,920.86		.08	179,920.94	179,920.94			
Second Mississippi district		58,464.32			58,464.32	58,464.32			
Protection of levees		155,307.00		3.00	155,310.00	154,562.57		747.43	747.43
Existing works		25,000.00			25,000.00	25,000.00			
Greenville, Miss		100,499.02	30,712.79		131,211.81	127,729.33		3,482.48	3,482.48
Repairs to floating plant		30,000.00			30,000.00	30,000.00			
Vicksburg Harbor, dredging and dam		284,312.12		25	284,312.37	247,006.62	*15,000.00	22,305.75	37,305.75
Delta Point	25,770.13	107,736.46			133,506.59	133,350.01		156.58	156.58
Lake Providence Reach		2,647,876.34	238,728 35	218.95	2,886,823.64	2,880,296.98		6,526.66	6,526.66
Care of plant and surveys		24,360.00			24,360.00	24,360.00			
Lake Bolivar Front		131,000.00	8,028.19	.04	143,028.23	122,738.51	20,000.00	289.72	20,289.72
Gauges		1,600.00			1,600.00	1,101.10	300.00	198.90	498.90
Observations and discharges		3,000.00			3,000.00	3,000.00			
Surveys, examinations, and inspections		10,149.46			10,149.46	9,087.20	1,000.00	62.26	1,062.26
Total third district	25,770.13	4,839,243.30	277,469.33	222.32	5,142,705.08	5,072,635.30	36,300.00	33,769.78	70,069.78
Survey Cubitt's Gap		137.14			137.14	137.14			
Unleveed fronts		1,000.00			1,000.00	1,000.00			
Observations at Carrollton		3,000.00			3,000.00	3,000.00			
Bonnet Carre Crevasse		15,000.00			15,000.00	15,000.00			
Natchez and Vidalia harbors	8,252.04				8,252.04	7,576.39		675.65	675.65
New Orleans Harbor	147,670.39	281,295.86	1,527.61	.04	430,493.90	381,974.28	45,000.00	3,519.62	48,519.62
Mouth of Red River	90,812.40	38,405.00			129,217.40	129,217.40			
Red and Atchafalaya rivers		437,500.00		.20	437,500.20	413,768.57	15,000.00	8,731.63	23,731.63
Gauges		2,000.00			2,000.00	1,599.98		400.02	400.02
Observations and discharges		9,000.00			9,000.00	9,000.00			
Levees, Tensas Front		889,422.00			889,422.00	860,304.58		29,117.42	29,117.42
Atchafalaya Front		176,800.00			176,800.00	176,800.00			
Protection of levees, Tensas Front		23,000.00			23,000.00	23,000.00			
levees		114,000.00			114,000.00	95,839.87		18,160.13	18,160.13
Surveys, examinations, and inspections		4,000.00			4,000.00	2,492.59		1,507.41	1,507.41
Total fourth district	246,734.83	1,994,560.00	1,527.61	.24	2,242,822.68	2,120,710.80	60,000.00	62,111.88	122,111.88
General service		42,410.19		11.26	42,421.45		39,978.82	2,442.63	42,421.45
Grand totals	295,137.49	12,243,346.93	779,421.47	675.88	13,318,581.77	12,942,963.43	238,727.76	136,890.58	375,618.34

*This amount is reserved for such repairs and extension of the Delta Point revetment as may prove to be necessary.

APPENDIX F.

REPORT OF CAPTAIN S. S. LEACH, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FIRST DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 1, 1890.

GENERAL: I have the honor to submit the following report of operations in the first district under the appropriation for improving Mississippi River, acts of August 11, 1888, and prior dates, from May 31, 1889, to May 31, 1890.

The part of the river to which this report relates, known as the first district, extends from Cairo to the foot of Island 40, a distance of 220 miles. Work has been carried on at various localities named in the acts or designated by the Commission. They are noted in geographical order beginning at the upper end of the district.

COLUMBUS, KENTUCKY.

The act of August 5, 1886, appropriated $18,750 for improving the river at this point. A further appropriation of $25,000 in the act of August 11, 1888, made a total of $43,750 available.

A project for the expenditure of this sum was submitted and was approved by the Commission November 28, 1888, and by the Secretary of War January 23, 1889. It provided for a revetment to consist of five spur-dikes of brush and stone so disposed as to cover the part of the bank threatened by caving, in length about 2,200 feet.

In the detail plan drawn up in pursuance of the approved project, each dike consisted of a floor or foundation mattress 200 feet long up and down stream, and extending from the low-water line 300 feet out into the river. This mattress was continued up the bank on a prepared slope of three horizontal to one vertical, as near to the top as possible. It could not go entirely to the top in all cases, on account of the proximity of a levee. On this mattress was laid a single brush-crib, 28 feet wide and 8 feet high, extending from the upper edge of the mattress to a point 240 feet beyond low-water mark. The crib was placed with its center line 12 feet above the center line of the mattress.

At the beginning of the fiscal year the stone for this work had been delivered and stored on the bank. During the last days of October, 1889, two pile-drivers were sent to Columbus from the plant working at Hickman, and the grading and driving of mooring and fender-piles were begun. By November 6 work was completed at Hickman and the entire plant transferred to Columbus. Rapidly rising river with heavy drift made it impossible to begin the mattress construction, and these adverse conditions continued until December 7, when the plant was swung into position and weaving begun. Thus the month in which it was hoped to do two-thirds of the work became a month of lost time.

Substantial progress in the execution of the project dates from December 7, 1889. The conditions were at no time favorable, as the river stood at 17 to 20 feet above low water, the current was rapid, considerable drift appeared from time to time, and the weather was stormy to an unusual degree. In one of his bi-monthly reports, the assistant in charge noted that there had been but four fair days during the fifteen. By January 4, 1890, a little less than a month, the floor mats of Nos. 5, 4, and 3, including shore connections, and the cribs of No. 4, were completed. The subaqueous crib of No. 5, or part below low water, was also done. At this time the river was rising rapidly, water for a bank-full stage was in sight, and the approach of the spring flood was plainly indicated. It was therefore decided to close for the season, but before doing so a partial foundation mattress, extending from top of bank to 100 feet beyond low water, was built and sunk on the site of No. 2 dike, to preserve the grade, which had been completed to prevent erosion on the site of the dike. The shore-crib of No. 5 was also built afloat and sunk in place, the water being then near the top of the bank. This work was completed, as well as the housing of lines and tools, by the 18th of January, and on the 20th the plant was moved to laying-up quarters at Island 30.

In less than a month of most unfavorable conditions both of river and weather, over half of the project was accomplished, a very favorable showing, made possible only by the fact that the force was thoroughly trained and fresh from work of greater intrinsic difficulty.

Operations can be resumed in time to have the work completed and the plant released before the date at which the next appropriation will become available.

An itemized statement of the expenditures is herewith, as well as the usual fiscal statements. The balance on hand is sufficient to complete the project, and the work

will, if successful, protect the water-front of Columbus from further recession. No further estimate is submitted.

A map of the locality, with a graphic exhibit of the work done and proposed, accompanies this report.

HICKMAN, KENTUCKY.

The act of August 5, 1886, contained a provision of $18,750 for work at this point, to which was added $70,000 by the act of August 11, 1888, making a total of $88,750 available at the latter date. A project for the work was approved by the Commission November 28, 1888, and by the Secretary of War December 19, 1888. In May, 1889, after a visit of inspection to the locality, the Commission modified the project, and in its final shape it provided for 1,000 feet of standard continuous revetment, extending from the lower side of the indurated clay point which projects into the river to a point near the old railroad depot.

The line to be protected had approximately a crescent shape, the high steep bluff touching the water-line at the upper end, succeeded by a shelf or terrace of lower elevation near the middle and an alluvial bank somewhat below the level of high water at the lower end. To meet these conditions the upper bank work was started at 25 feet width at the upper end, bringing it about 10 feet above low water, and was gradually widened, its upper edge increasing in elevation until, at a point somewhat above the middle, it attained a width of 90 feet, with its upper edge 10 feet below the high water of 1882.

Hydraulic grading began on September 2, 1889. From the outset this part of the work proved to be unusually difficult. At the upper end the material to be removed being of the bluff formation was unusually hard and, in places, the large quantity of water necessary to dislodge it caused a serious sloughing near the water surface, so that jet grading had to be abandoned and a considerable quantity of earth removed with shovels and sluices. Near the middle of the work, for a distance of about 100 feet, there appeared a stratum of greasy clay, inclined toward the river and outcropping 8 feet above the grade. On this stratum the superincumbent earth slid toward the river at the rate of 2½ feet a day, the projecting portion breaking off at intervals and falling upon the grade. After much time and labor had been spent in attempting to maintain a clear grade, it was decided to clean it off quickly, just after a fall of earth, place the fastenings and lay the upper part of the shore-work and then allow the earth to fall on top of it. Near the lower end of the revetment some isolated piles of riprap, deposited years ago by the railroad company, were encountered, and it was thought necessary to remove the parts protruding above the adopted grade. At no part of the bank covered was the grading of the usual character. The result is seen in the cost of grading as shown in the exhibit, which is two and a half to three times greater than usual.

On account of the projection of the point at which the mooring barges were to rest, the rapid recession of the bank above, and the width of the proposed mattress (300 feet), it was not deemed prudent to depend upon the method of fastening heretofore employed, by extending lines from the mooring barges and mat-head directly to shore, as the lead would have been very oblique and the length of lines very great. A new system was adopted, depending on two large Chinese anchors. These held two barges in position, and from the barges the head and shackle lines were worked. The preparation of this anchorage and the grading and partial construction of shore-work occupied a force of the usual strength until October 4, when the weaving of the subaqueous mattress was begun. It was completed on the 21st and sunk on the 24th of the same month. It was 300 feet wide and made continuous with the shore-work for a distance of 750 feet, beyond which the outer edge was continued on the same line and two offsets made on the inside, which were afterward covered with connecting mats. This design was necessary, as it was not feasible to build so wide a mat around so short a curve. The two connecting mats, the remaining shore-work, and the recovery of the anchors and cables were accomplished by November 6, and the work at Hickman was closed on that day.

An itemized statement of the expenditures and other financial exhibits are herewith. A map of the locality showing the extent and position of the work is also submitted.

The statement shows the work to have cost $24.10 per foot of bank protected. Considering the unusual cost of grading, the width of the mat, the cost of providing the anchorage, and the small amount of work involved, this figure compares very favorably with previous work.

No inspection of the work has been made since the subsidence of the late flood, but private advices from Hickman represent the work as having been entirely successful, no displacement of any part of it having been observed.

PLUM POINT REACH.

The portion of river now under improvement by this title extends from the 150th to the 170th mile below Cairo, having been extended 6 miles up-stream since last report, by the protection of Daniel's Point.

In my last annual report full mention was made of the allotment of $300,000 for this reach, and of the approval and partial execution of a project for its expenditure. On May 20 and 22, 1889, further allotments for Plum Point Reach were made, aggregating $148,586.85. The allotments were approved June 5, 1889, at which date the last annual report had left my hands. The above allotments from the appropriation of August 11, 1888, for this reach aggregated $448,586.85, which, in accordance with the expressed wish of the Commission, was to be directed to the following objects, in the amounts set opposite each:

Fletcher's revetment	$131,000.00
Elmot and No. 30 dikes	130,000.00
Repairs to Bullerton No. 2 dike	2,000.00
Yankee Bar Dike	5,000.00
Additions and repairs to plant	32,000.00
Daniel's Point revetment	100,000.00
Plum Point revetment	20,000.00
Construction and operation of sand-pump	9,000.00
Protection of works after close of season	19,586.85
	448,586.85

Fletcher's Revetment.—The work contemplated under this head consists of 7,400 feet of continuous revetment in five pieces. The first, known as Section A, is an extension of a piece built in 1884, and is 3,000 feet in length, of which 2,000 feet were constructed during the last fiscal year and described in the last Annual Report, as were also Sections B, C, and D, each 1,100 feet long and separated by intervals of 300 and 400 feet, the head of section B being 3,800 feet below the foot of Section A, with a piece of old work projecting into the river between them, as explained in last report. There remained to complete the project 1,000 feet of Section A and all of Section E, 1,100 feet in length, beginning 500 feet below the foot of Section D.

Graders were put in at Section A on May 20, 1889, and after completing the 1,000 feet there were transferred to Section E, which was finished on the 11th of June. At this section some trouble was experienced by reason of a thick stratum of sand near the water-surface, which made it impracticable to use the jet. Sluicing was resorted to for about 300 feet of the distance. Everything was in readiness to begin weaving at Section A on June 1, but the river was still too high and too full of drift to make it prudent to begin, and these conditions seemed likely to prevail for some time. The party and plant were therefore transferred to other work in less exposed situations and were not again available until the middle of July, when the mattress construction began at Section A. Much preliminary work had already been done, including the piling on the grade of a quantity of brush, which was used in making a direct connection with the river mat as fast as constructed and in carrying the shore-work up high enough to be out of the reach of any rise which could be reasonably expected at that season. This method of construction dispenses entirely with connecting mats, which have always seemed a source of weakness. This mat was completed and sunk by August 2. The remaining shore-work and ballasting were completed on the 13th.

On the same day the weaving plant was swung into position at Section E, and on the 26th the river mat, 1,100 feet long, was sunk, the connection and partial shore-work having been completed as at Section A. The remaining shore-work and ballasting were completed by September 13th, as well as a connecting mat built to fit the bottom of a pocket 200 feet above the foot of the section, which caved out just before the grading begun. The grade and shore-work were returned a short distance on the sides of the pocket. The rest of it was not graded.

Itemized statements of expenditures for the part of this project executed last year were submitted with my last annual report and, as then stated, the cost per unit was reserved until completion of the project. Corresponding data for this year's operations are herewith, and by combining the two the following figures result:

Total length of revetment built.....feet..	7,400
Total field cost of same	$108,657.89
Resulting field cost per foot of work	$14.68
Total length of Sections B, C, D, and E, of interrupted revetment..feet..	4,400
Total length of bank protected by same.....do..	6,000
Cost of protecting 1 foot of bank by interrupted revetment	$10.76

The saving by the interrupted as against continuous revetment is seen to be in this case $3.92 per foot of bank. With longer intervals the saving will be greater.

Plum Point Revetment.—A short piece of revetment was projected here to check local caving, which threatened the stability of the three crossings immediately below. At the time the work was begun the portion of bank needing protection was about 1,500 feet long, two in approximately straight lines of equal length, meeting in a very obtuse angle. The lower half had the desired trend, its prolongation being almost exactly in the line of the crossing. It was decided to protect this part and postpone the upper half until it should have caved back to the same line with the protected part.

With this view a river mat 150 feet wide was begun on the 1st of July. It was completed to a length of 800 feet and sunk on the 12th. As caving was active at the time the work was begun, the river-mat was laid in advance of the grading. The latter was begun as soon as the mat was down and the connecting mats and shore-work were completed on the 9th of August.

Daniel's Point Revetment.—The project approved for this locality contemplates the construction of a continuous revetment from the extreme point up, an estimated distance of 5,000 feet, with a probable cost of $100,000. The delivery of stone began in the latter part of May, 1889, and by the end of the last fiscal year it was mostly stored on the bank.

On the 23d of July grading was begun at the lower end, and on the same day a diver with a blasting equipment began the removal of snags, which was completed on the 9th of August. The latter days of the month were occupied in the preliminary work of dressing the slope and storing brush on it, and on the 31st the weaving plant was put in operation. The plan adopted was to build the revetment in five sections, beginning at the lower end. The method used was that of lateral continuity, in which the shore revetment is built wholly or in part and connected to the river-mat before sinking the latter, as already described in connection with work on Sections A and E, Fletcher's Bend. The river-mat was 200 feet wide, but was held out by a line of piling so as to give a protection equal to that of a 225-foot mat. This method was adopted on account of the limited length of mooring and weaving barges available. The first mattress, 1,100 feet long, was sunk on the 19th of September, and the second, begun on the 21st, was sunk on the 2d of October. The third section was begun on the 5th and sunk on the 19th of October, and the fourth section begun on the 28th. Early in November the river began to rise, with much drift running, and at the same time work was retarded by local rains, causing loss of time and shortening the brush supply. On the 9th of October, when 800 feet of the fourth section was completed, the condition of the mooring barges became somewhat critical and it was decided to sink the upper part. The section was successfully completed and the rest of it sunk on the 11th.

By this time the water-surface had risen almost to the upper edge of the 4,000 feet of partial shore-work, and as the reports from above indicated a considerable further rise, the entire force was set to work to complete the shore-work to the top of the bank. The rapid rise and unfavorable weather continued, and it was with great difficulty that the work was kept ahead of the water, the force being worked on Sundays and on several days of steady rain. By the end of November this work had been completed, the condition of affairs at that date being 4,300 feet of completed work, 1,100 feet of finished grade, the river high and rising, and work temporarily suspended. As the river fell some caving took place along the grade of Section 5, which was also injured throughout its length by wave-wash. Considerable work was required to restore it.

Weaving could not be resumed until December 19, when the fifth and last section was begun. It was completed and sunk on the 2d of January, 1890. The work had been extended up-stream to reach a deep pocket in the original bank-line, where a return could be carried back to protect the head of the work from being flanked. A short mat was built to carry the under-water protection around the flank, and the upper bank was graded to a cone, on which the upper work was laid. At the head of the first or down-stream section there was also a pocket, around which the grade could not well be carried. The river mat was made continuous across its chord, an irregularly-shaped mat was made and sunk on its floor, and a protection was carried up around its sides on a sand-beach or natural grade to about mid-stage, On the lower flank a conical return was made, as at the head of the work just described. The upper flank was graded and left without protection. These constructions and the completion of shore-work of Section 5 occupied the time until January 14, when the plant was withdrawn and the force disbanded.

The work as completed forms a continuous protection 5,300 feet in length. It is on an extreme point which was rapidly caving and has an unprotected bend, heretofore caving, above it. It is designed to form a fixed guiding line at all stages to deflect the current over the bar, and will greatly contribute to the stability of the channel, more so than the same amount of work in any other place could possibly do. As it must from its situation receive continuously the full impact of the stream, it was made somewhat heavier than usual, and especial attention was given to details of

construction, involving at times a slightly greater cost. The cost was further increased by the rehandling of stone, which was delivered before the work began, piled on the bank and again wheeled partly on barges and partly on the mat and shore-work direct. The total field cost was $19.05 per foot of bank protected.

Elmot and Island, thirty dikes.— The design and purpose of these dikes, the construction of the shore protections, and the greater part of the foot-mats for them, and the necessary postponement of the pile-driving on account of the stage of water not having been sufficient to float out the piles, were noted in the last report.

In the latter half of June, 1889, the construction of foot-mats was resumed and almost completed when the falling river necessitated a withdrawal of the plant. On January 30, 1890, a sufficient stage having been reached to enable the contractor to float out the piles, operations were again resumed, the completion of the foot-mats receiving first attention. Actual pile-driving began on February 3 and continued until the middle of March, when, the river being at extreme flood stage and all work which could be advantageously done at that stage being accomplished, operations were temporarily suspended. They were resumed on April 17, and at the date of this report the dikes are within a few days of completion. Data as to cost must be deferred for a future report. The locations of the dikes are shown on the map of the reach herewith.

The routine surveys on the reach, having for their object a connected history of the improved channel, have continued. The principal results are collected in an appended table at depths and velocities at different dates. The party has obtained other important data, both here and elsewhere.

None of the works have been injured during the year. As previously reported, the completion of the Fletcher's Bend revetment has been delayed to await the final destruction of a detached piece of old work projecting into the river and the recession of the bank to a fair line. During the last working season a deficit of stone occurred and some was removed from this old work, thus hastening its destruction. During the late flood it finally disappeared, and at the date of this writing the shore-line has the position shown on the map. The project can be completed at any time when funds are available.

The Plum Point Reach was selected for improvement because it was known to be the most difficult piece of river below Cairo and with the idea that a favorable result at this point would be a crucial test and would establish beyond peradventure the success of the system under which it had been achieved. Work has been in progress with some interruptions from lack of funds for eight years. The three features of the Commission's plan—protection of banks, contraction of channel-way, and confinement of floods by levees—have nearly reached the development contemplated at the outset. The question, "What is the result?" will surely be asked and will be anticipated. From the stand-point of practical navigation the results may be summed up in the statement that as an obstruction to navigation the Plum Point Reach is a thing of the past. For the past three years the depth at extreme low water has not fallen below 9 feet and at higher stages the depths have been proportionately greater. The depths are practically double those which obtained at the same places before the improvement was begun. The thalweg now remains unchanged during all stages, from extreme low water to extreme flood. The former shoal and shifting crossings have become so permanent both in depth and direction that pilots seldom sound them or take any note of them in their reports.

While these facts are highly gratifying they do not present the results of the work in their largest and most important aspect. That the control of the stream at all stages will cause a permanent increase in the size of the bed and in its discharging capacity is the fundamental principle upon which the improvement was projected and by which it can alone be fully justified. That such increase has taken place in the Plum Point Reach there is ample evidence. It is apparent to the most casual observation of one familiar with the low-water aspect of the reach in 1880 and 1890. It is shown unmistakably by a comparison of the surveys taken at frequent intervals during the progress of the work. But it appears with the greatest clearness and certainty by a comparison of low-water slopes, since that quantity is a function of all the variables which enter the problem and is perhaps the most sensitive index which the river presents of the ultimate effect of changes going on in its bed.

In a diagram submitted herewith will be found the low-water profiles of 1879, 1886–'87, and 1889. The first represents conditions prevailing before the improvement was undertaken while the others represent those of the improved river. The waters of 1879, 1887, and 1889 were, as seen by their elevations at Fulton, a point below the influence of the works, nearly of the same volume. That of 1886 was greater in volume, but small enough to feel and manifest the effect of changes in the bed. If it had fallen as low as the others at Fulton it would evidently have corresponded closely with 1887 and 1889 above. These profiles show, as the result of the control of the stream by the works and in addition to the deepening of the channel for navigation, a lowering of

1 to 3 feet in the surface of low water of equal volume, so distributed as to produce a marked decrease of slope, which is an unfailing sign of an enlarged channel.

What has been accomplished here can safely be promised elsewhere and with much less expenditure of time and money. Not only must other points be intrinsically less difficult than this, as before noted, but the knowledge of principles gained and the improvements of methods developed in this undertaking would make it easy to do it over again in half the time and at two-thirds the cost.

There has been a marked increase in the river tonnage during the past year. The records containing information are so kept that a correct estimate of traffic can not well be made except for the entire river below Cairo as a unit. No new lines have been established during the year in the first district, but some of the existing lines have added new boats and have had their entire equipments more fully employed than ever before. Based on unofficial data and an extensive personal knowledge of the traffic in the district, the amount of 3,500,000 tons is confidently stated as a minimum for the total traffic of all kinds passing through the whole or a part of the first district during the twelve months covered by this report. There will be found herewith a tabulated statement of the shipments from the port of Cairo, the principal one in the district, kindly furnished by Mr. E. W. Halliday, of that place.

There are submitted herewith itemized statements of expenditure, a map of the Plum Point Reach, showing the location of the various works, and a series of photographs illustrating the methods of construction.

There are also submitted consolidated statements of expenditures for the entire district, classified as to the manner of making them as required by law, a general balance-sheet, and a table of values of plant.

Very respectfully, your obedient servant,

SMITH S. LEACH,
Captain of Engineers.

General C. B. COMSTOCK,
President Mississippi River Commission.

APPROPRIATION FOR IMPROVING MISSISSIPPI RIVER, FIRST DISTRICT.

Money statement.

July 1, 1889, balance available		$270,601.80
June 5, 1889, amounts allotted by Mississippi River Commission to Plum Point Reach, viz:		
From unallotted reserve	$129,586.85	
From general service allotment	19,000.00	
November 30, 1889, amount refunded on account of overpayment	1.00	
		148,587.85
Total		418,589.65
Amounts transferred as follows:		
March 15, 1890, from levees, Plum Point Reach, to protection of levees, fourth district	19,000.00	
March 22, 1890, from Plum Point Reach to protection of levees, second district	2,500.00	
March 31, 1890, from maintenance of existing works to protection of levees, third district	27,250.00	
April 22, 1890, from Plum Point Reach to protection of levees, fourth district	17,000.00	
June 30, 1890, amount expended from June 1, 1889, to date, exclusive of liabilities:		
Outstanding June 1, 1889	276,306.14	
June 30, 1890, amount expended by general service, as follows:		
On account Hickman, Ky	3,288.83	
On account Columbus, Ky	2,599.08	
Outstanding liabilities	4,096.75	
		352,040.80
June 30, 1890, balance available		66,548.85
Amount that can be profitably expended in fiscal year ending June 30, 1892		1,000,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

General balance sheet.

PLUM POINT REACH.

1889.			1890.		
June 1	To balance, including estimated liabilities	$114,313.70	Mar. 22	By amount transferred to protection of levees, second district	$2,500.00
June 5	To amount allotted by Mississippi River Commission	148,586.85	Apr. 22	By amount transferred to protection of levees, fourth district	17,000.00
Nov. 30	To amount refunded on account of overpayment	1.00	June 30	By amount expended from June 1, 1889, to date	231,236.33
			June 30	By liabilities	3,776.75
			June 30	By balance	8,388.47
		262,910.55			262,901.55

MAINTENANCE OF EXISTING WORKS, FIRST DISTRICT.

1889.			1890.		
June 1	To balance	$27,250.00	Mar. 31	By amount transferred to protection of levees, third district	$27,250.00

LEVEES, PLUM POINT REACH.

1889.			1890.		
June 1	To balance	$19,894.60	Mar. 15	By amount transferred to protection of levees, fourth district	$19,000.00
			June 30	By amount expended to date	818.63
			June 30	By balance	75.97
		19,894.60			19,894.60

SURVEY OF ST. FRANCIS FRONT.

1889.			1890.		
June 1	To balance, including estimated liabilities	$643.56	June 30	By amount expended to date	$643.56

OBSERVATIONS AND DISCHARGES, FIRST DISTRICT.

1889.			1890.		
June 1	To balance, including estimated liabilities	$500.92	June 30	By amount expended to date	$500.92

GAUGES, FIRST DISTRICT.

1889.			1890.		
June 1	To balance, including estimated liabilities	$1,651.50	June 30	By amount expended to date	$720.00
			June 30	By liabilities	180.00
			June 30	By balance	751.50
		1,651.50			1,651.59

General balance sheet—Continued.

SURVEYS AND EXAMINATIONS, FIRST DISTRICT.

1889. June 1	To balance	$2,744.91	1890. June 30	By amount expended to date	$903 46
			June 30	By balance	1,841.45
		2,744.91			2,744.91

HICKMAN, KENTUCKY.

1889. June 1	To balance, including estimated liabilities	$78,007.78	1890. June 30	By amount expended to date	$26,071.19
			June 30	By amount expended by general service	3,288.83
			June 30	By balance	48,647.78
		78,007.78			78,007.78

COLUMBUS, KENTUCKY.

1889. June 1	To balance, including estimated liabilities	$39,324.87	1890. June 30	By amount expended to date	$23,709.63
			June 30	By amount expended by general service	2,599.08
			June 30	By liabilities	140.00
			June 30	By balance	12,876.16
		39,324.87			39,324.87

FIRST DISTRICT.

Disbursements made under appropriations for improving Mississippi River, acts of August 5, 1886, and August 11, 1888.

[June 1, 1889, to June 1, 1890.]

Contracts made with—	For what made.	Disbursements under contract.	Total.
J. J. Carr	Piling	$32.46	$32.46
Madison Marine Railway Company (balance)*	Hull and cabin of tow-boat.	6,000.00	6,000.00
Hunter & Trey	Willow brush and poles.	20,664.63	20,664.63
Bryant & Picket	do	7,064.43	7,064.43
Total		33,761.52	33,761.52

*Original contract for $10,000; part payment reported in 1889.

Disbursements made otherwise than under contract.

For what expended.	By public notice and sealed proposals.	In open market.	Liabilities.	Total.
Material and supplies	$30,871.06	$26,617.75	$875.70	$58,364.51
Subsistence	24,328.52	10,890.52	1,429.16	36,648.20
Services		132,316.95	3,620.00	135,936.95
Tools and appliances	2,961.02	10,739.41	7.50	13,707.93
Miscellaneous	641.35	3,026.50	477.60	4,145.45
Total	58,801.95	183,591.13	6,409.96	248,803.04

Abstract of proposals for furnishing willow brush and poles for Plum Point Reach, received in response to advertisement dated June 12, 1889, and opened July 12, 1889, by Capt. Smith S. Leach, Corps of Engineers, U. S. Army.

No.	Name and address of bidder.	10,000 cords of willow brush.	2,000 cords of willow poles.	Total.	Remarks.
		Per cord.	*Per cord.*		
1	Hunter & Frey, Memphis, Tenn..	$1.07	$1.65	$14,000	Accepted.
2	Franklin & Vance, Garvey, Ark..	1.15	2.00	7,750	Bids made for one-half of required quantities.

Abstract of proposals for furnishing willow brush and poles for Hickman and Columbus, Kentucky, received in response to advertisement dated June 20, 1889, and opened July 20, 1889, by Captain Smith S. Leach, Corps of Engineers, U. S. Army.

No.	Name and address of bidder.	10,000 cords of willow brush.	2,000 cords of willow poles.	Total.	Remarks.
		Per cord.	*Per cord.*		
1	A. C. Terrell, Memphis, Tenn.....	$1.20	$1.62½	$15,250	
2	Whitney Gilbreath, Ava, Ill.....	1.20	1.50	15,000	
3	Agnus McDonald, Memphis, Tenn.	1.20	1.75	15,500	
4	Nathan W. Tucker, St. Louis, Mo.	.....	.....	.....	No prices stated in proposals.
5	Bryant & Picket, Highman, Ky..	1.05	1.25	6,500	Bids made for one-half of required quantities *accepted.*
6	Vance & Franklin, Garvey, Ark.	1.15	1.70	14,150	

IMPROVING MISSISSIPPI RIVER.

Itemized statement of expenditures on works of construction in first district, from June 1, 1889, *to June* 1, 1890.

Articles.	Care and repairs of plant.	Surveys.	Fletcher's Bend Revetment.	Elmot Chute Dike.	Island 30 Chute Dike.
Coal	$1,221.18	$628.57	$267.96	$767.19	$334.93
Iron	961.37	63	1.50	7.25	3.31
Lumber	2,587.59	.....	.....	9.16	96
Nails	92.52	.....	.....	.....	.....
Oakum	635.17	.....	.....	.....	.....
Oil and supplies	305.20	42.00	16.33	83.57	50.45
Paint	386.98	.....	.....	.....	.....
Pipe fittings	328.38	.....	.....	.....	.....
Rope	.....	.....	78.60	.....	21.60
Spikes	212.71	.....	66.00	230.55	104.33
Towing	7,044.80	.....	1,237.05	1,290.82	774.41
Piling	46.40	.....	.....	3,761.14	2,028.88
Wire and wire stands	.....	.....	1,555.77	2,123.73	1,540.79
Brush	.....	.....	5,440.06	127.25	.....
Poles	.....	.....	872.41	148.00	.....
Stone	.....	.....	7,942.70	64.80	.....
Miscellaneous	1,080.83	32.31	1.25	24.51	11.62
Superintendence and labor	45,080.02	4,714.94	11,249.68	11,002.11	5,443.69
Total	59,983.15	5,418.45	28,729.31	19,640.08	10,314.97

Itemized statement of expenditures on works of construction, etc.—Continued.

Articles.	Daniel's Point Revetment.	Plum Point Revetment.	Hickman, Ky.	Columbus, Ky.	Total.
Coal	$2,088.36	$385.17	$576.15	$633.15	$6,902.66
Iron	42.34	1.20	59.50	30.17	1,107.27
Lumber	4.95	.....	139.49	.....	2,742.15
Nails	1,40	.....	11.80	.....	105.72
Oakum	3.67	.....	.....	.....	638.84
Oil and supplies	93.04	7.65	123.00	75.38	796.62
Paint	.....	.....	6.66	.....	393.64
Pipe fittings	.....	.....	.....	.....	328.38
Rope	57.44	45.00	66.25	117.71	386.60
Spikes	147.20	16.50	35.75	72.30	885.34
Towing	4,427.27	521.53	679.73	1,267.47	17,243.08
Piling	.....	.....	36.40	121.44	5,994.26
Wire and wire strands	4,818.07	572.83	959.91	910.53	12,481.63
Brush	20,343.34	1,930.59	3,285.45	2,777.25	33,903.94
Poles	2,401.29	245.73	476.00	525.62	4,669.05
Stone	14,602.83	2,189.49	4,482.75	3,716.28	32,998.85
Miscellaneous	216.27	1.20	93.37	301.19	1,762.55
Superintendence and labor	47,448.92	4,802.77	11,136.09	12,156.84	153,035.06
Total	96,696.39	10,719.66	22,168.30	22,705.33	276,375.64

Statement of expense for work done at Hickman, Kentucky, from August 28, 1889, to May 31, 1890.

Items.	Administration.	Care of plant.	General repairs.		Tow-boat service.		Subaqueous mattress.					
							Chinese anchor.		Mattress.		Total.	
	Cost.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.
Labor	$1,778.98	$690.44	.....	$658.87	.....	$1,268.32	.....	$375.92	.....	$3,262.07	.....	$3,637.99
Subsistence	80.81	205.39	.....	27.53	.....	162.22	.....	60.72	.....	44.06	.....	104.78
Brush, cords	.....	.....	.....	.....	.....	.....	.....	.....	1,812	1,902.60	1,812	1,902.60
Poles, do	.....	.....	.....	.....	.....	.....	.....	.....	250	312.50	250	312.50
Stone, cubic yards	.....	.....	.....	.....	.....	.....	20	29.22	1,697	2,478.92	1,717	2,508.14
Wire, pounds	.....	.....	.....	.....	.....	.....	462	13.75	22,098	608.08	22,560	621.83
Wire strands, do	.....	.....	.....	.....	.....	.....	.....	.....	4,061	145.79	4,061	145.79
Spikes and nails, do	.....	.....	300	11.80	.....	.....	.....	.....	1,000	27.50	1,000	27.50
Lumber, feet	.....	.....	4,088	49.39	.....	.....	2,785	27.85	4,200	47.25	6,985	75.10
Coal, bushels	.....	.....	.....	.....	2,729	272.90	.....	.....	.....	.....	.....	.....
Iron, pounds	.....	.....	.....	.....	.....	.....	1,240	15.80	240	4.80	1,480	20.60
Miscellaneous	127.97	.....	.....	72.57	.....	6.66	.....	.....	.....	.....	.....	.....
Manilla rope, pounds	.....	.....	.....	.....	.....	.....	.....	.....	700	72.55	700	72.55
Oils and supplies	.....	14.61	.....	.....	.....	29.02	.....	.....	.....	.....	.....	.....
Piling, feet	.....	.....	.....	.....	.....	.....	.....	.....	455	36.40	455	36.40
Total	1,987.76	910.44	.....	820.16	.....	1,739.12	.....	523.26	.....	8,942.52	.....	9,465.78
Percentage	8.27	3.78	.....	3.41	.....	7.23	.....	2.16	.....	37.25	.....	39.41
Work done	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,736 squares made. 2,624 squares covered.	
Cost per unit	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	$4.47 per square made. $4.66 per square covered.	

Statement of expense for work done at Hickman, Kentucky, from August 28, 1889, to May 31, 1890—Continued.

Items.	Shore-work.						Grand total.		Percentage.
	Grading.		Mattress.		Total.				
	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	
Labor		$2,358.91		$2,212.50		$4,571.41		$12,606.01	52.51
Subsistence		261.00		44.00		305.00	1,694	885.73	3.68
Brush, cords			1,317	1,382.85	1,317	1,382.85	3,129	3,285.45	13.67
Poles, do			131	163.50	131	163.50	381	476.00	1.97
Stone, cubic yards			1,508	2,202.90	1,508	2,202.90	3,225	4,711.04	19.61
Wire, pounds			5,524	155.10	5,524	155.10	28,084	776.93	3.22
Wire strands, do							4,061	145.79	.60
Spikes and nails, do			300	8.25	300	8.25	1,600	47.55	.20
Lumber, feet	1,000	15.00			1,000	15.00	71,775	139.49	.58
Coal, bushels	2,292	229.20			2,292	229.20	5,021	502.10	2.07
Iron, pounds							1,480	20.60	.08
Miscellaneous								207.20	.86
Manilla rope, pounds							700	72.55	.30
Oils and supplies		76.58				76.58		120.21	.50
Piling, feet							455	36.40	.15
Total		2,940.69		6,169.10		9,109.79		24,003.05	100.00
Percentage		12.21		25.69		37.90			100.00
Work done	970 linear foot				1,378 squares made. 143 feet wide		4,114 squares made. 4,002 squares covered. 970 linear feet.		
Cost per unit	$3.03 per linear foot.				$8.54 per square. $12.13 per linear foot.		$5.71 per square made. $6 per square covered. $24.74 per linear foot.		

Statement of expense for work done at Columbus, Kentucky, from October 14, 1889, to May 31, 1890.

Items.	Administration.	Care of plant.		General repairs.	To w-boat service.		Mattress work.							
							Subaqueous.		Grading.		Shore-work.		Total.	
	Cost.	Amt.	Cost.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.
Labor	$1,686.89	.....	$1,291.87	$1,431.52	.....	$1,601.26	.....	$3,032.99	.....	$1,458.96	.....	$1,010.99	.....	$5,502.94
Subsistence	144.20	.....	59.06	340.43	.....	414.97	.....	52.60	.....	202.74	.....	50.00	.....	305.34
Brush ....cords	.....	.....	.....	.....	.....	.....	1,310	1,375.50	80	84.00	705	740.25	2,095	2,199.75
Poles....do	.....	.....	.....	.....	.....	.....	148	185.62	.....	.....	85	106.25	233	291.87
Stone ....cubic yards	.....	.....	.....	.....	.....	.....	1,411	2,089.69	.....	.....	450	666.45	1,861	2,756.14
Wire ....pounds	.....	.....	.....	.....	.....	.....	11,418	319.79	.....	.....	5,708	159.82	17,126	479.61
Wire strand....do	.....	.....	.....	.....	.....	.....	2,034	73.03	.....	.....	.....	.....	2,034	73.03
Spikes ....do	.....	40	1.20	.....	.....	.....	1,300	36.40	.....	.....	200	5.50	1,500	41.90
Lumber....feet	.....	500	7.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Coal ....bushels	.....	.....	.....	.....	4,586	458.65	200	20.00	1,545	154.50	.....	.....	1,745	174.50
Iron ....pounds	.....	325	7.83	.....	.....	.....	260	5.20	.....	.....	.....	.....	260	5.20
Rope ....do	.....	.....	.....	.....	.....	.....	820	102.65	.....	.....	.....	.....	820	102.65
Oils and supplies	.....	.....	4.15	27.10	.....	26.26	.....	.....	.....	9.62	.....	.....	.....	9.62
Piling ....feet	.....	.....	.....	.....	.....	.....	759	60.72	.....	.....	.....	.....	759	60.72
Miscellaneous	141.42	.....	213.17	46.25	.....	37.27	.....	.....	.....	.....	.....	.....	.....	.....
Total	1,972.73	.....	1,584.78	1,845.30	.....	2,538.41	.....	7,354.19	.....	1,909.82	.....	2,739.26	.....	12,003.27
Percentage	8.47	.....	6.80	7.92	.....	10.90	.....	31.57	.....	8.20	.....	11.76	.....	51.53

Statement of expense for work done at Columbus, Kentucky, from October 14, 1889, to May 31, 1890—Continued.

Items.	Crib dikes.						Grand total.		Percentage.
	Shore cribs.		Subaqueous cribs.		Total.				
	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	
Labor	.....	$319.00	.....	$739.20	.....	$1,058.20	.....	$12,572.68	53.97
Subsistence	.....	7.82	.....	40.00	.....	47.82	.....	1,317.04	5.65
Brush (cords)	183	192.50	367	385.00	550	577.50	2,645	2,777.25	11.92
Poles (do)	60	75.00	127	158.75	187	233.75	420	525.62	2.26
Stone (cubic yards)	200	296.10	450	666.45	650	962.55	2,511	3,718.69	15.95
Wire (pounds)	4,000	112.11	8,000	224.24	12,000	336.35	29,126	815.96	3.50
Wire strand (do)	.....	.....	600	21.54	600	21.54	2,634	94.57	0.41
Spikes (do)	350	10.25	750	20.15	1,100	30.40	2,640	73.50	0.32
Lumber (feet)	.....	.....	.....	.....	.....	.....	500	7.50	0.03
Coal (bushels)	.....	.....	.....	.....	.....	.....	6,331	633.15	2.72
Iron (pounds)	40	.80	100	2.00	140	2.80	725	15.83	0.07
Rope (do)	.....	.....	120	15.06	120	15.06	940	117.71	0.51
Oils and supplies	.....	.....	.....	.....	.....	.....	.....	67.13	0.29
Piling (feet)	.....	.....	759	60.72	759	60.72	1,518	121.44	0.52
Miscellaneous	.....	.....	.....	.....	.....	.....	.....	438.11	1.88
Total	.....	1,013.58	.....	2,333.11	.....	3,346.69	.....	23,291.18	100.00
Percentage	.....	4.35	.....	10.01	.....	14.36	.....	.....	100.00
Work done	.....	.....	.....	.....	.....	.....	130,000 feet crib. 800 linear feet mattress. 2,717 square mattress.		
Cost per unit	.....	.....	.....	.....	.....	.....	$0.04 per cubic foot. $22.65 per linear foot. $6.70 per square.		

Approximate value of plant belonging to the United States and used upon the improvement of the Mississippi River, first district.

Class of property.	No.	Approximate value May 31, 1890.	Class of property.	No.	Approximate value May 31, 1890.
Steamer *Titan*	1	$25,000	Derrick-boats	1	$2,251
Steamer *P. Kirns*	1	5,787	Barges	23	12,738
Steamer *Itasca*	1	5,996	Machine-shop boats	1	2,400
Steamer *Abbott*	1	3,025	Floating dock	1	7,638
Launch *Titania*	1	454	Skiffs	24	240
Pile-drivers	28	43,814	Tools and appliances and machinery	....	13,323
Quarter-boats	14	19,754	Office furniture	....	56
Mattress-boats	6	8,874	Surveying instruments	....	240
Mooring-barges	2	4,388			
Sand-pump	1	2,793	Total		176,122
Graders	2	17,349			

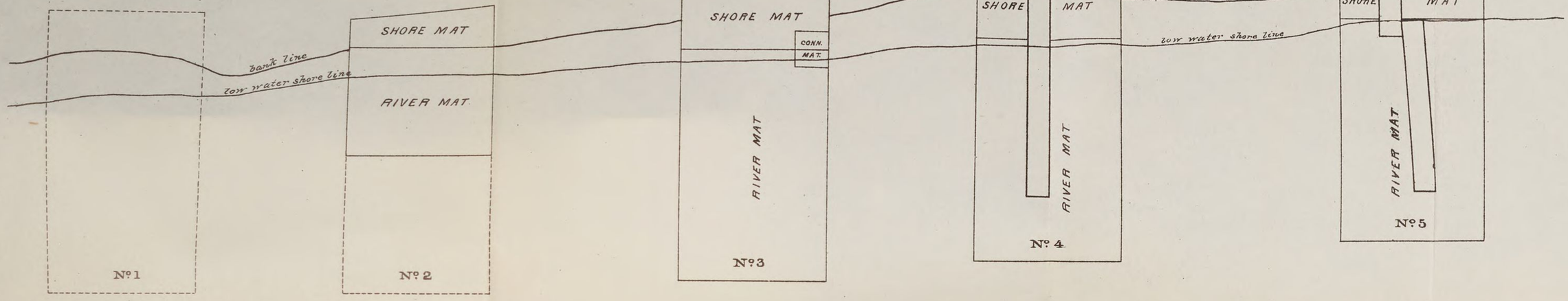
Table showing comparative least channel depths and velocities in various channels of the improved portion of Plum Point Reach, Mississippi River.

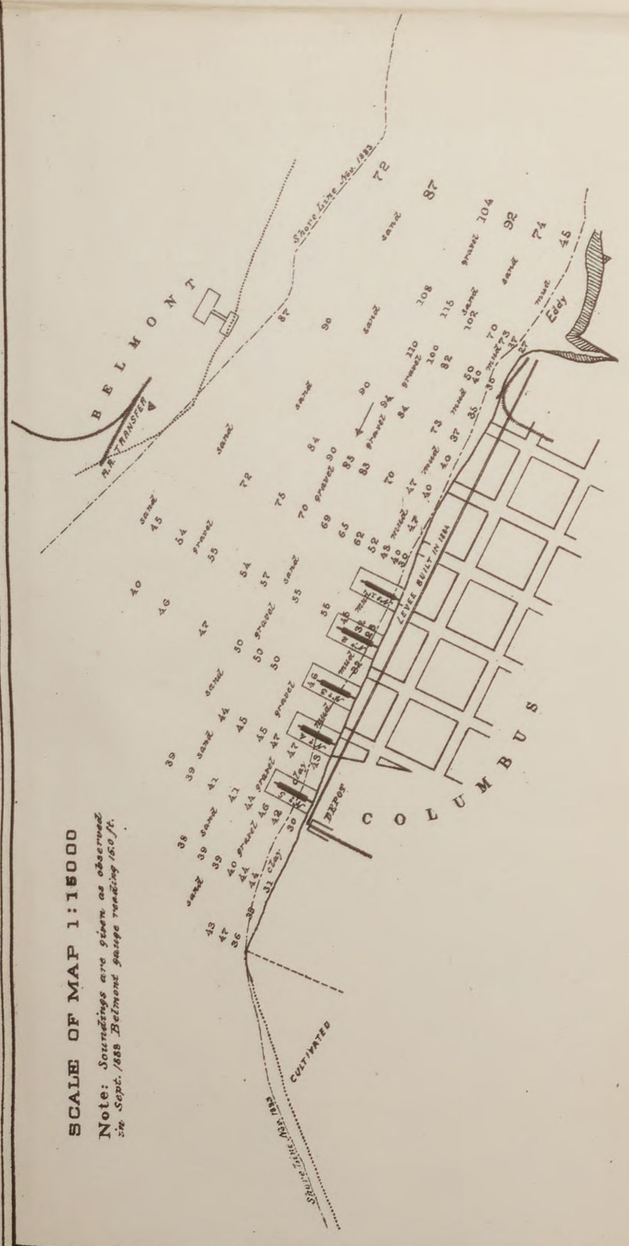
Localities.		First group.				Second group.			
		Lower Plum Point Crossing.		Bullerton Channel.		Island 30 Channel.		Lynch Channel.	
Date.	Gauge.	Depth.	Velocity.	Depth.	Velocity.	Depth.	Velocity.	Depth.	Velocity.
1889.									
June 5	15.75	31.1	4.03	11.5	3.20	31.0	5.84	18.0	4.58
11	16.20	31.0	4.11	11.5	3.23	33.0	5.80	16.0	4.40
14	17.75	33.0	4.00	14.0	.....	35.0	5.46	18.0	.....
17	17.70	34.0	4.03	16.0	3.26	33.5	5.81	18.0	4.71
24	21.50	37.0	4.18	18.0	3.78	38.5	5.65	25.0	4.84
July 5	14.50	31.0	3.92	8.0	3.15	29.0	4.73	15.0	4.65
9	11.60	28.0	4.04	3.5	2.76	27.0	4.52	10.0	4.49
15	11.25	26.5	3.89	.....	.....	26.5	4.85	8.0	4.56
19	12.25	27.5	4.00	5.5	3.04	27.0	5.00	9.5	4.70
29	12.50	27.5	3.96	5.5	.....	28.0	4.92	9.0	.....
Aug. 2	11.20	28.0	4.14	4.0	2.86	26.0	4.45	9.0	4.33
9	10.70	26.0	4.27	2.5	1.82	27.0	5.53	8.0	3.68
16	7.90	22.0	4.45	.....	.....	24.0	5.30	5.0	3.10
21	6.70	20.0	5.30	.....	.....	23.0	5.42	3.0	3.37
29	4.30	19.0	5.88	.....	.....	24.0	5.50	1.0	2.94
Oct. 3	2.00	13.0	3.98	.....	.....	16.5	4.76	1.5	3.21
9	1.80	12.0	4.48	.....	.....	15.0	5.11	3.0	2.28
14	0.00	12.0	4.53	.....	.....	13.0	4.95	2.0	1.55
22	—2.00	10.0	4.14	.....	.....	13.0	3.75	2.0	1.60
29	—1.70	10.0	3.95	.....	.....	13.0	3.83	2.5	1.86
Nov. 7	1.00	13.0	3.21	.....	.....	19.0	4.60	6.0	2.13
15	8.90	22.0	3.29	0.7	.....	28.0	4.72	12.5	3.79
22	16.60	32.0	3.37	8.5	3.56	36.0	3.56	20.0	5.53
29	16.55	31.0	4.57	9.0	2.59	35.0	3.33	21.0	4.95
Dec. 5	18.10	32.0	4.37	11.0	3.67	35.0	4.60	20.0	2.34
12	10.80	24.5	5.53	2.5	1.31	29.0	5.03	11.0	4.14
19	10.25	23.0	4.14	2.0	1.48	30.0	5.03	11.0	4.29
27	10.60	24.0	4.49	2.5	2.09	28.0	4.49	11.0	4.37
1890.									
Jan. 2	10.00	23.0	4.41	2.5	1.63	28.0	4.72	10.5	3.91
17	26.00	38.0	4.56	18.0	.....	44.0	5.11	25.0	6.07
24	29.30	43.0	4.26	20.0	3.52	45.0	5.38	29.0	4.91
31	29.30	44.0	4.53	23.0	3.05	48.0	4.91	28.0	.....
Feb. 7	24.30	39.0	4.22	18.0	.....	39.0	4.22	26.0	.....
13	26.00	40.0	4.26	20.0	4.06	40.0	4.87	27.0	5.80
21	28.00	42.0	3.95	23.0	4.14	45.0	4.10	32.0	4.08
Apr. 28	23.25	38.0	4.49	11.0	4.64	36.0	5.49	28.0	4.68
May 6	23.78	37.0	4.91	16.0	4.33	36.0	6.19	25.0	4.14
13	18.45	30.0	4.17	12.0	3.75	32.0	5.18	20.0	5.43

NOTES.—The depths reported are the least found in the line of deepest water, or those which limited navigation for the time being. The velocities were measured on the same line and near the shoalest point. They were all taken with the current-meter running at a depth of 5 feet below the surface. They are individual velocities taken to ascertain the relative draught of water in the different channels, and are useful for that purpose only. They have no relation to the average velocity or discharge.

PLAN. SCALE 1IN. = 150FT.

CENTER LINE OF LEVEE





MISSISSIPPI RIVER COMMISSION

MAP OF COLUMBUS FRONT

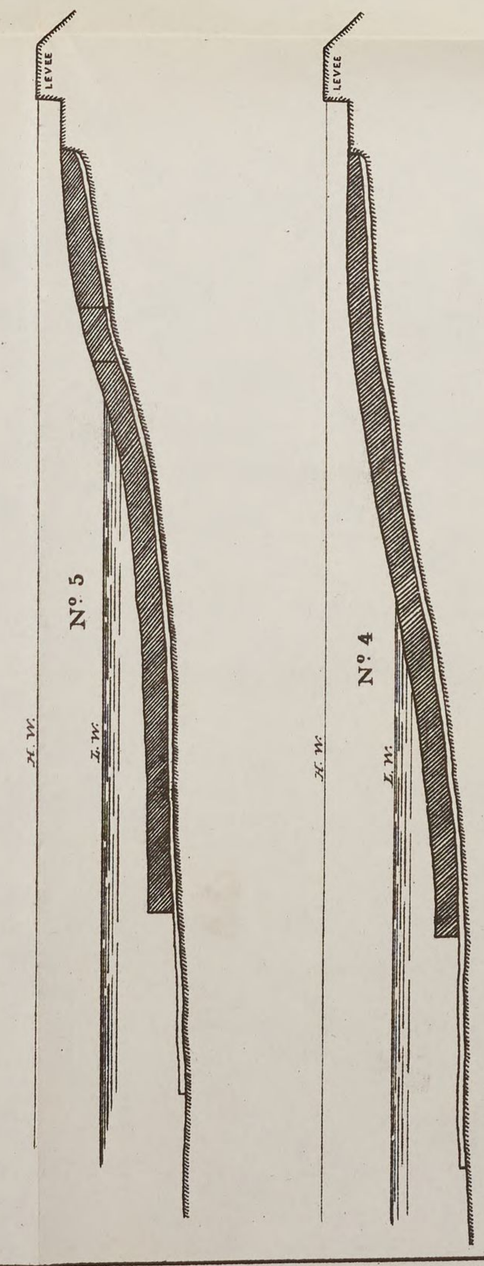
showing location, plan and sections of

CRIB DIKES

built under the direction of

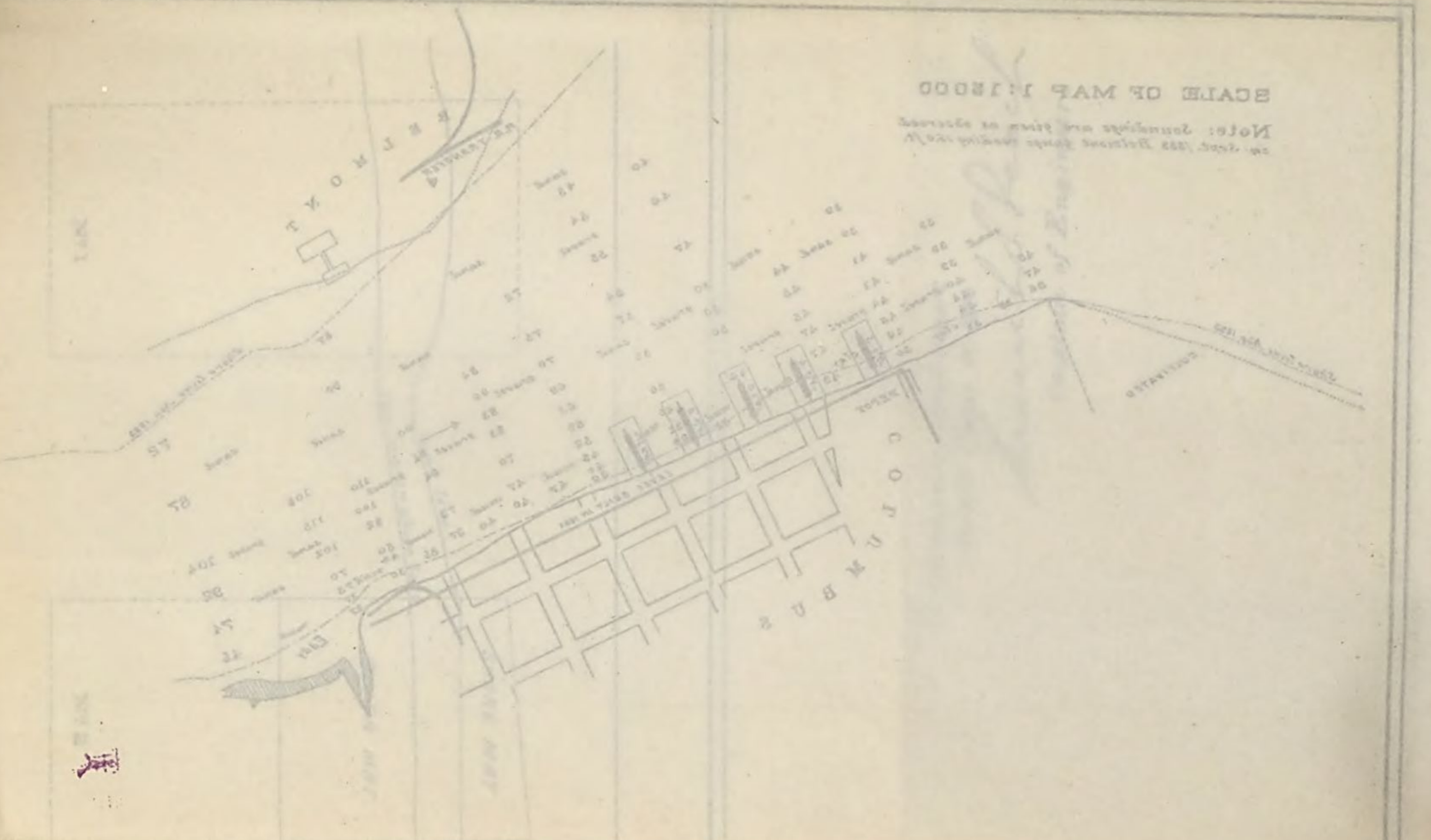
Capt. SMITH S. LEACH,
Corps of Engrs U.S.A.
By
C.W. STEWART Asst. Engr.
1889 ~ 1890

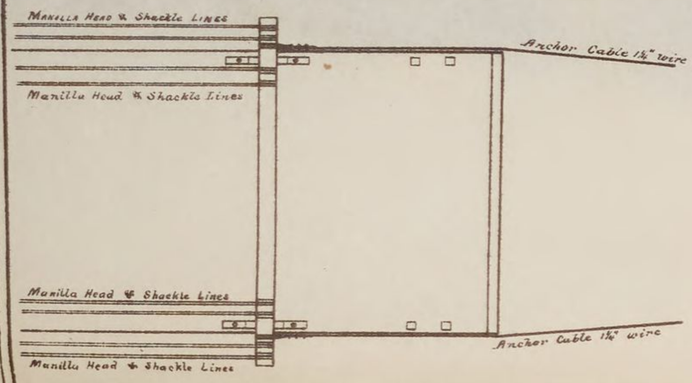
To accompany annual report
dated June 1st 1890
Smith S. Leach
Captain of Engineers



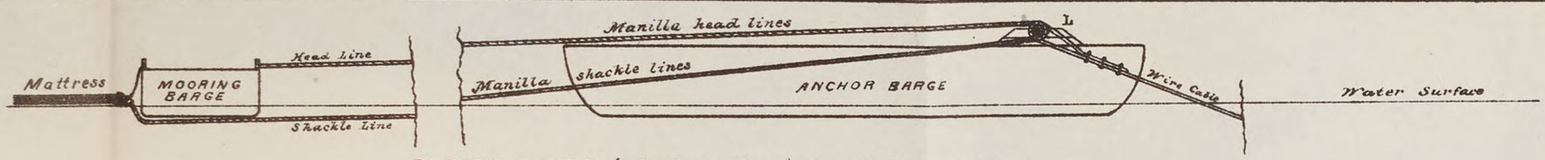
SECTIONS. SCALE 1IN. = 60FT.

Slopes of Nºs 2 and 3 are practically identical with Nº 4 slope.

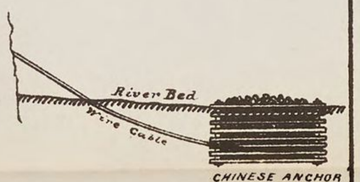

COLUMBUS



PLAN OF ANCHOR BARGE AT "L"



BROKEN SKETCH (IN ELEVATION) OF MOORING PLANT



CHINESE ANCHOR

MISSISSIPPI RIVER COMMISSION

MAP OF
HICKMAN HARBOR

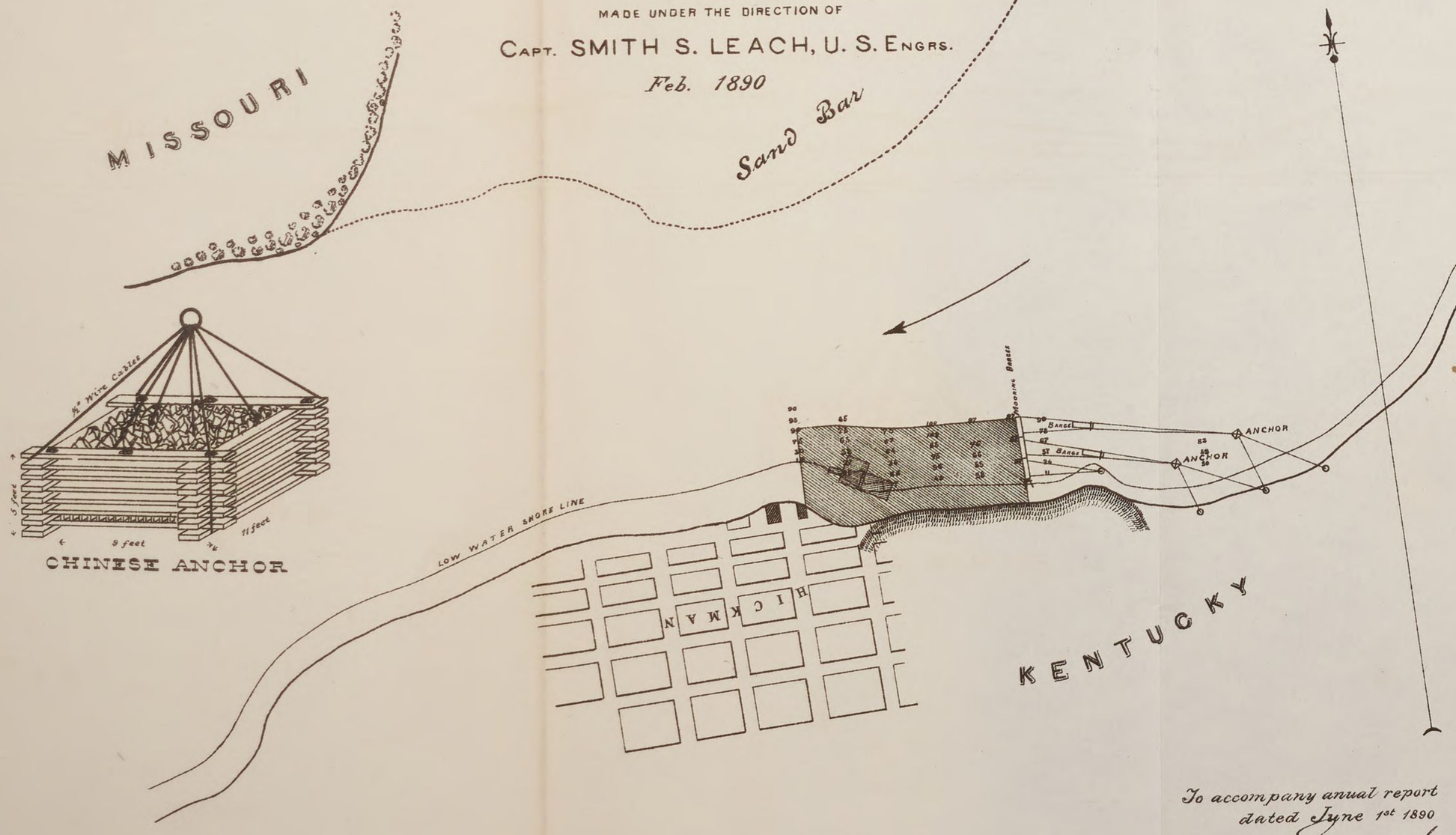
Showing location of Mattress
and
Details of Mooring Plant

SCALE 1:7500

MADE UNDER THE DIRECTION OF

CAPT. SMITH S. LEACH, U. S. ENGRS.

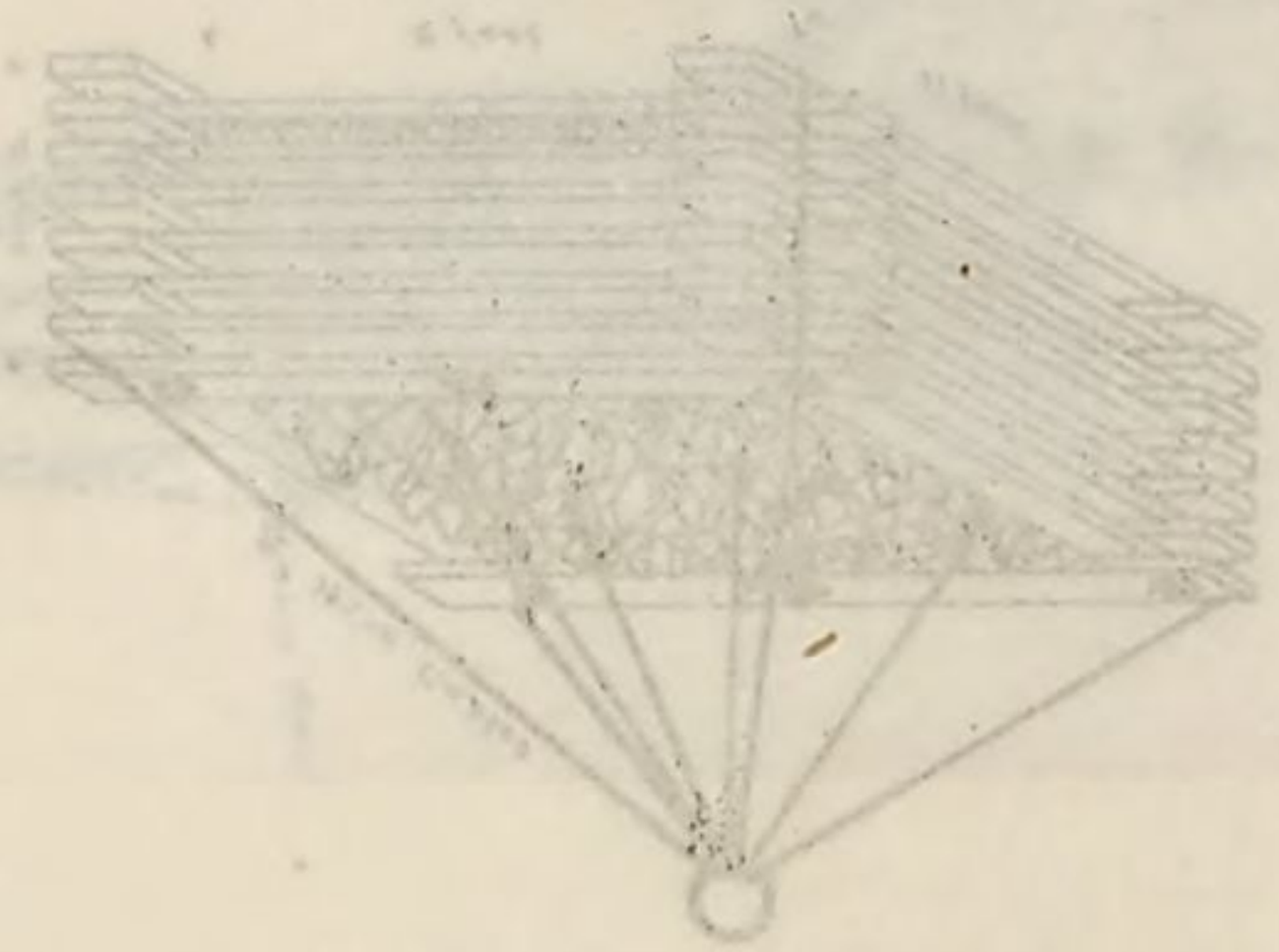
Feb. 1890



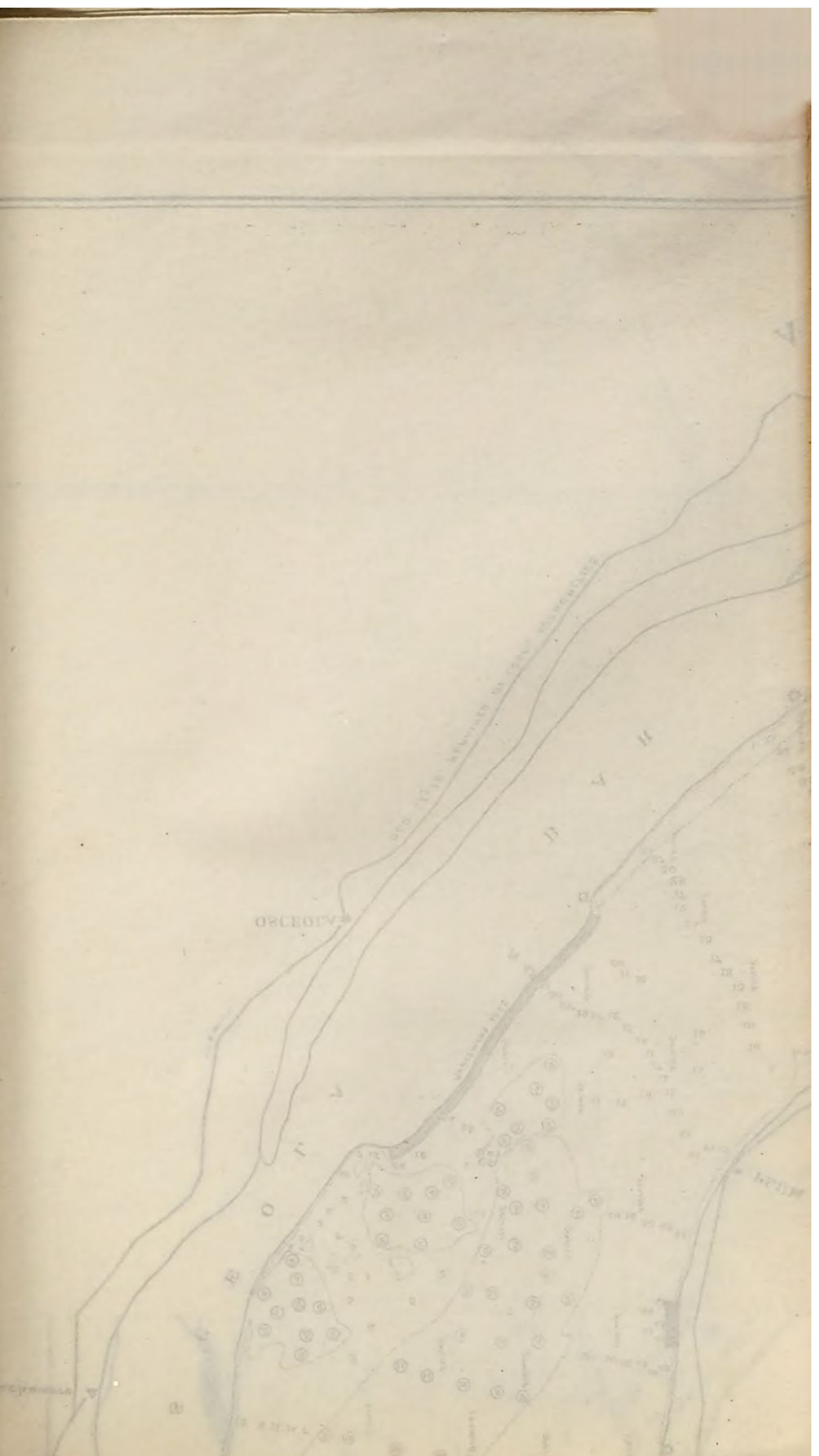
CHINESE ANCHOR

To accompany annual report
dated June 1st 1890

Smith S. Leach
Captain of Engineers



3



M.R.C.

PLUM POINT REACH

LOW WATER PROFILES OF 1879, 86, 87 & 89

230

Prepared from observations made under the direction of

CAPT. SMITH S. LEACH, CORPS OF ENGINEERS U.S.A.

By Assistants

C.W. Sturtevant & C.W. Stewart

SCALES — HOR. 1 IN = 2 MILES; VERT. 1 IN = 1 FOOT

LEGEND:-

Elevations are above Cairo Datum plane and were taken at extreme low water.

——————— Profile low water 1879
— — — — — " " 1886
— · — · — · — " " 1887
— · · — · · — " " 1889

225

240 Cairo Datum

235 Cairo Datum

1879
1886
1887
1889

5 mi. below Daniels Pt.

Daniels Pt.

Ashport

Gold Dust

Fletchers (9.22)

10 mi. below Daniels Pt.

Bird's Pt. Crossing

15 mi. below Daniels Pt.

Elmot

Plum Pt. (9.44)

Mo. 6 Dike (9.53)

20 mi. below Daniels Pt.

25 mi. below Daniels Pt.

30 mi. below Daniels Pt.

Crawford St.

Mo. Old Creek

Fulton

Dixie

Mo. Hatchee R.

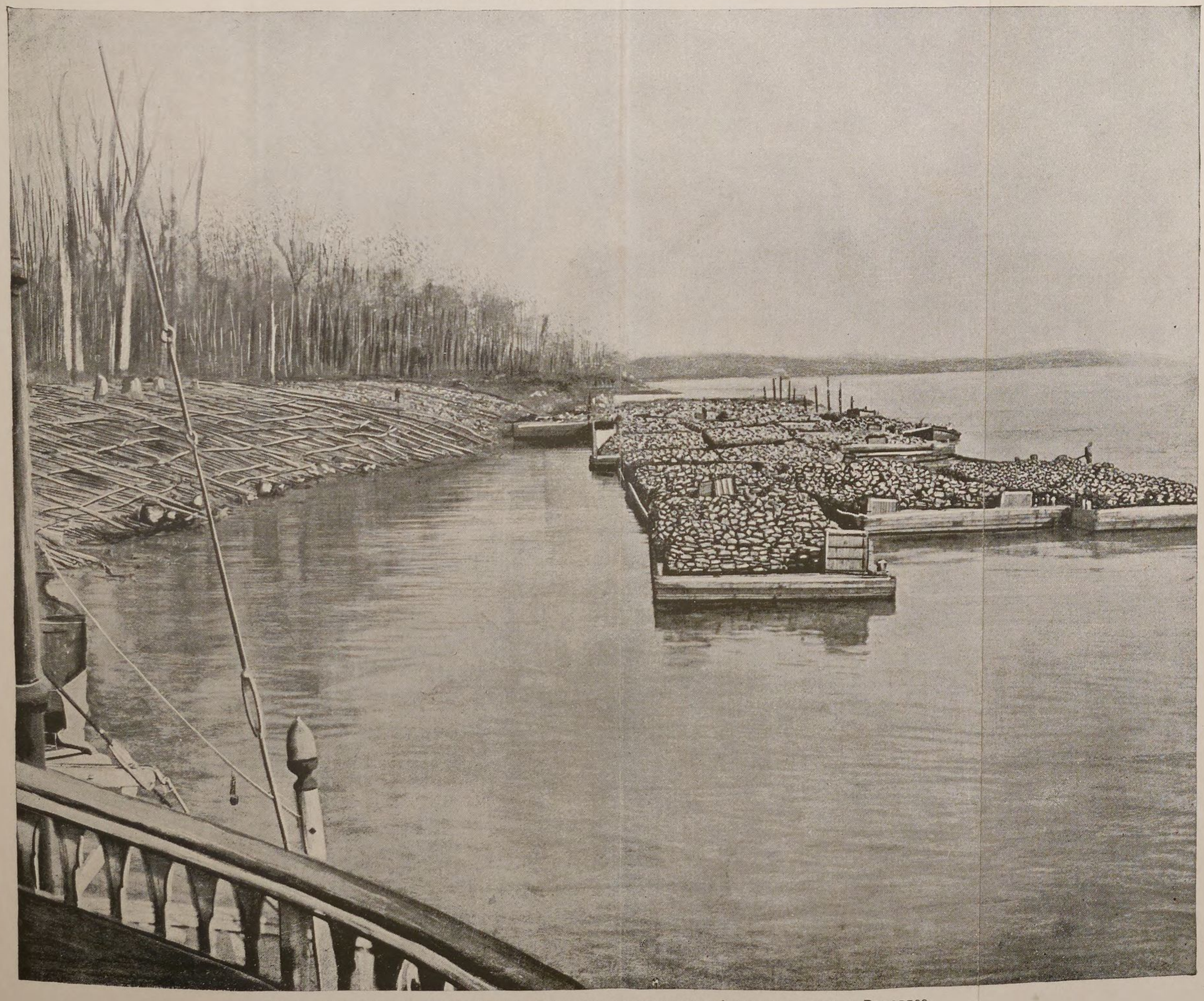
Randolph

To accompany report dated June 1st 1890

Smith S. Leach

Captain of Engineers.

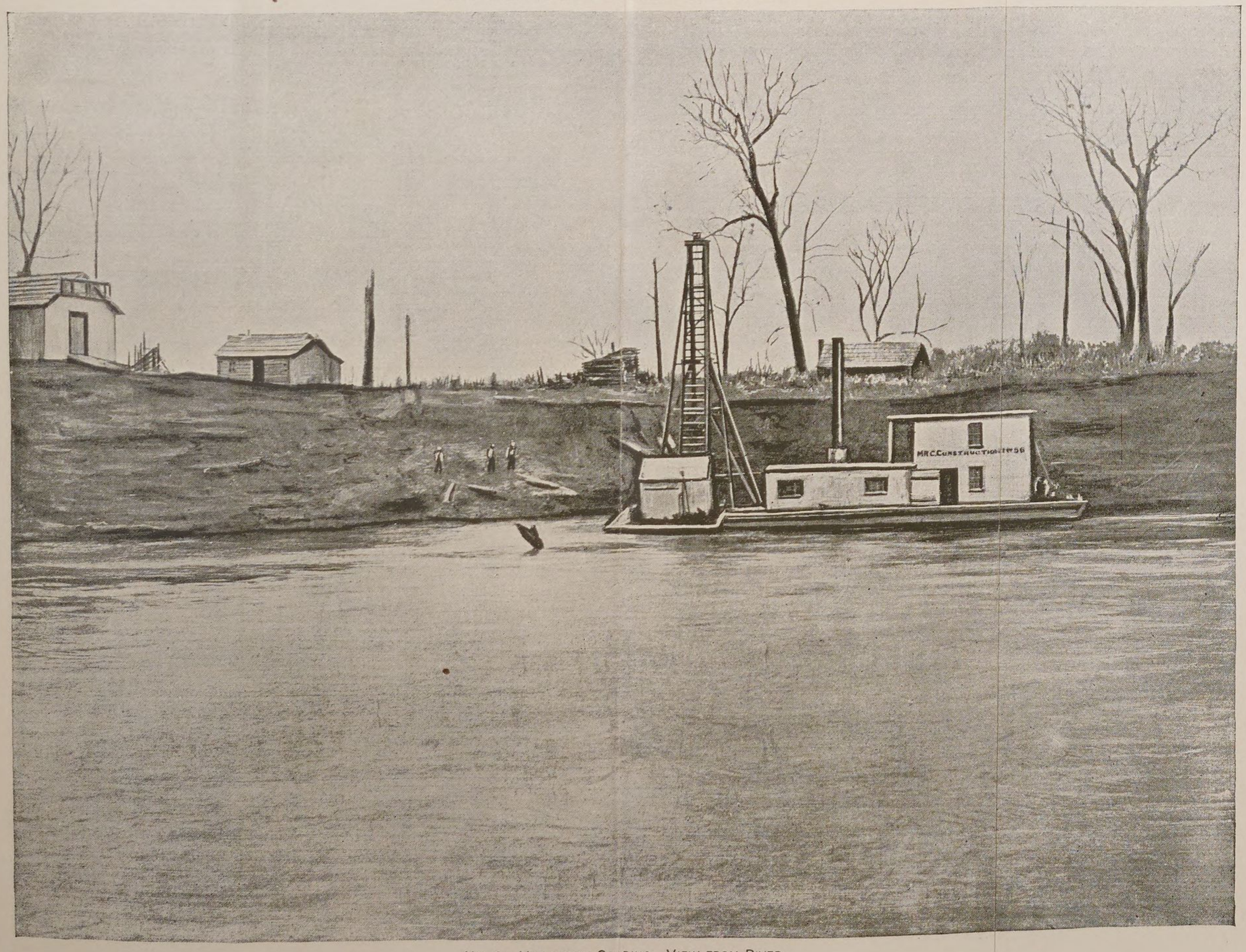
GAYLORD BROS.
PAT. JAN 21, 1908



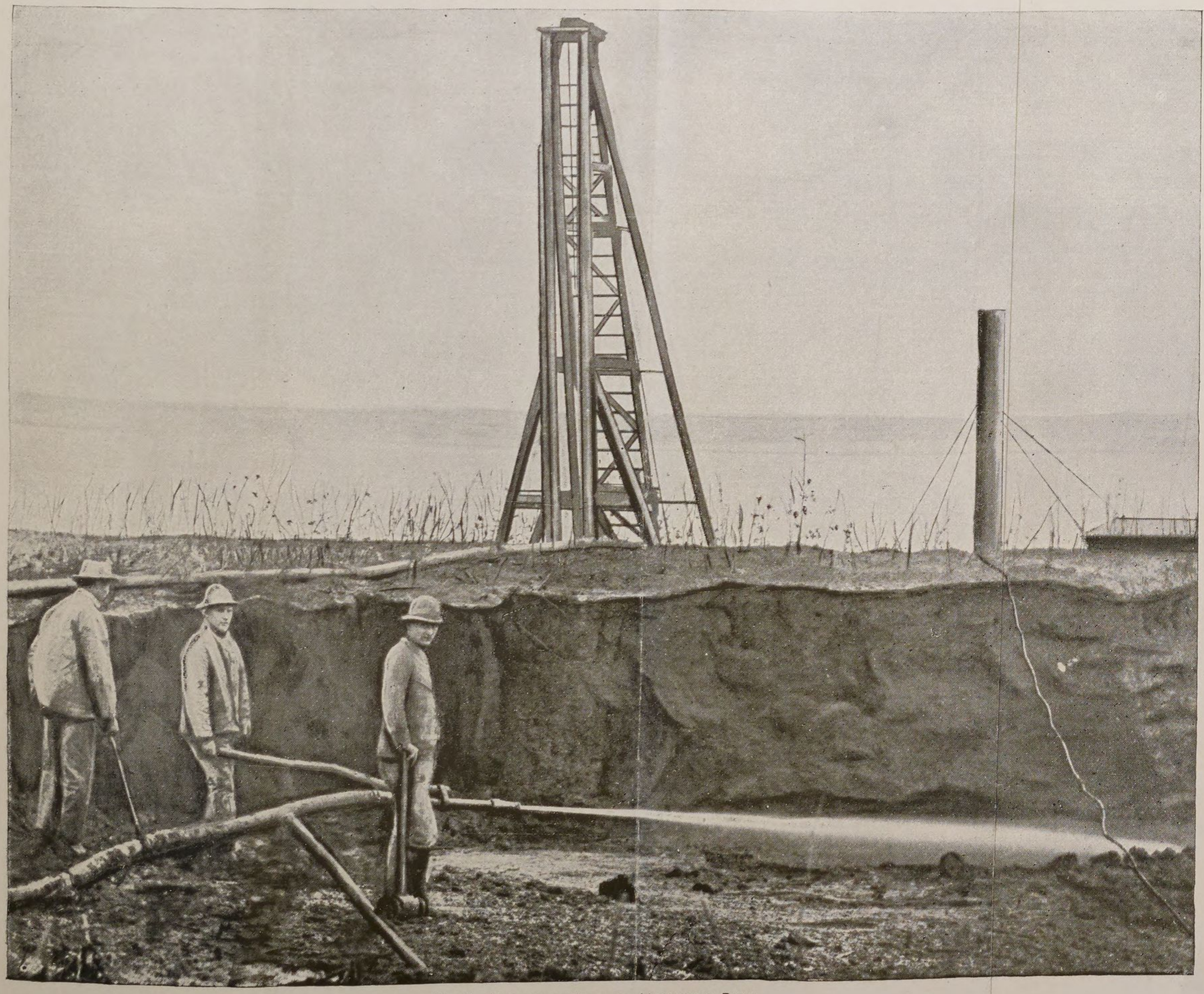
No. 1. Stone Fleet. Brush-work of Revetment completed on Left; ballasting in Progress.



No. 2. Upper Bank-work in Progress. Load Brush and Weaving Barge and Quarter Boat in Middle Distance.

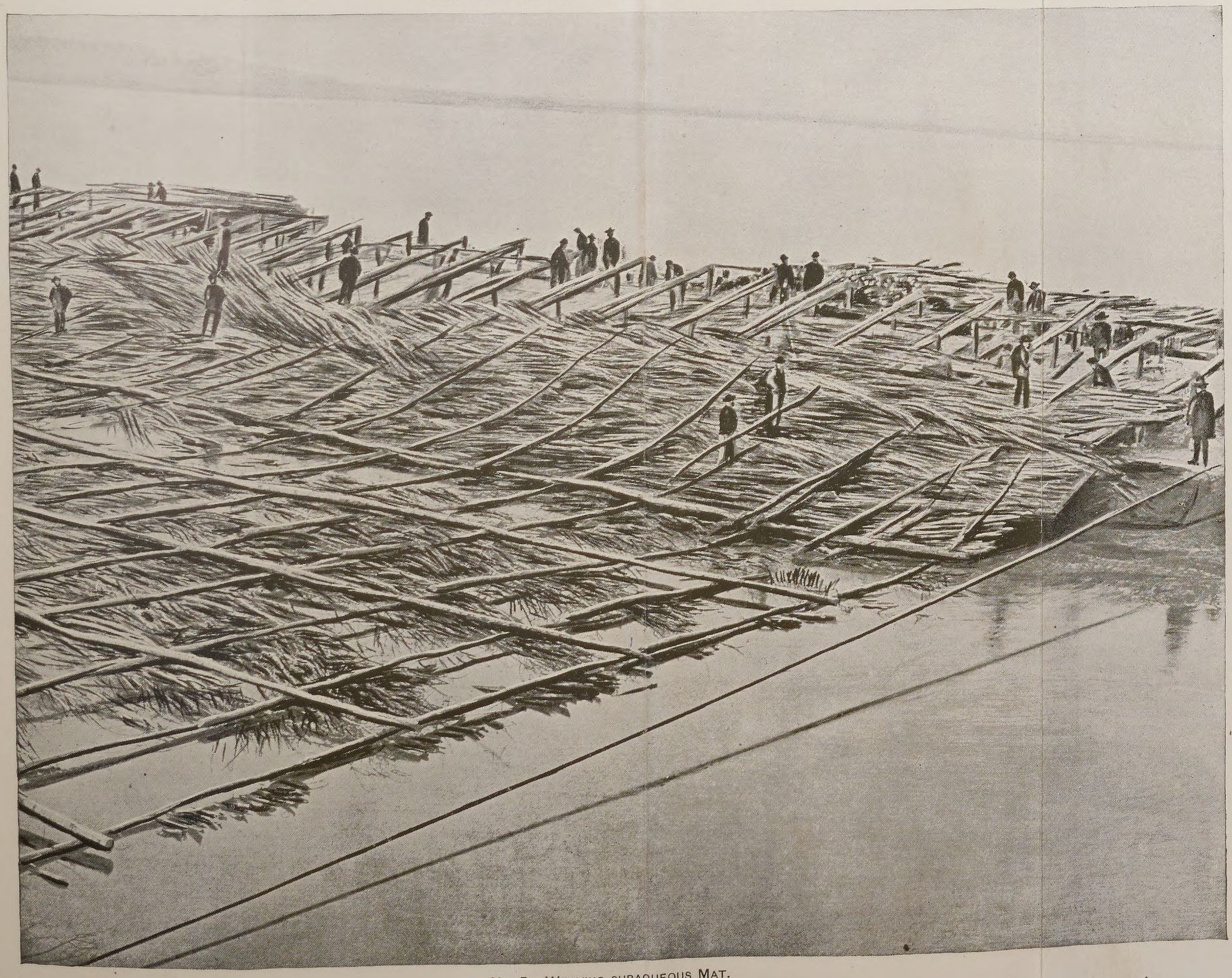


No. 3. Hydraulic Grading. View from River.



No. 4. Hydraulic Grading. View from Bank.

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.



No. 5. Weaving subaqueous Mat.

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.



No. 6. Weaving subaqueous Mat. Portion in Foreground ballasted ready for sinking.

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.

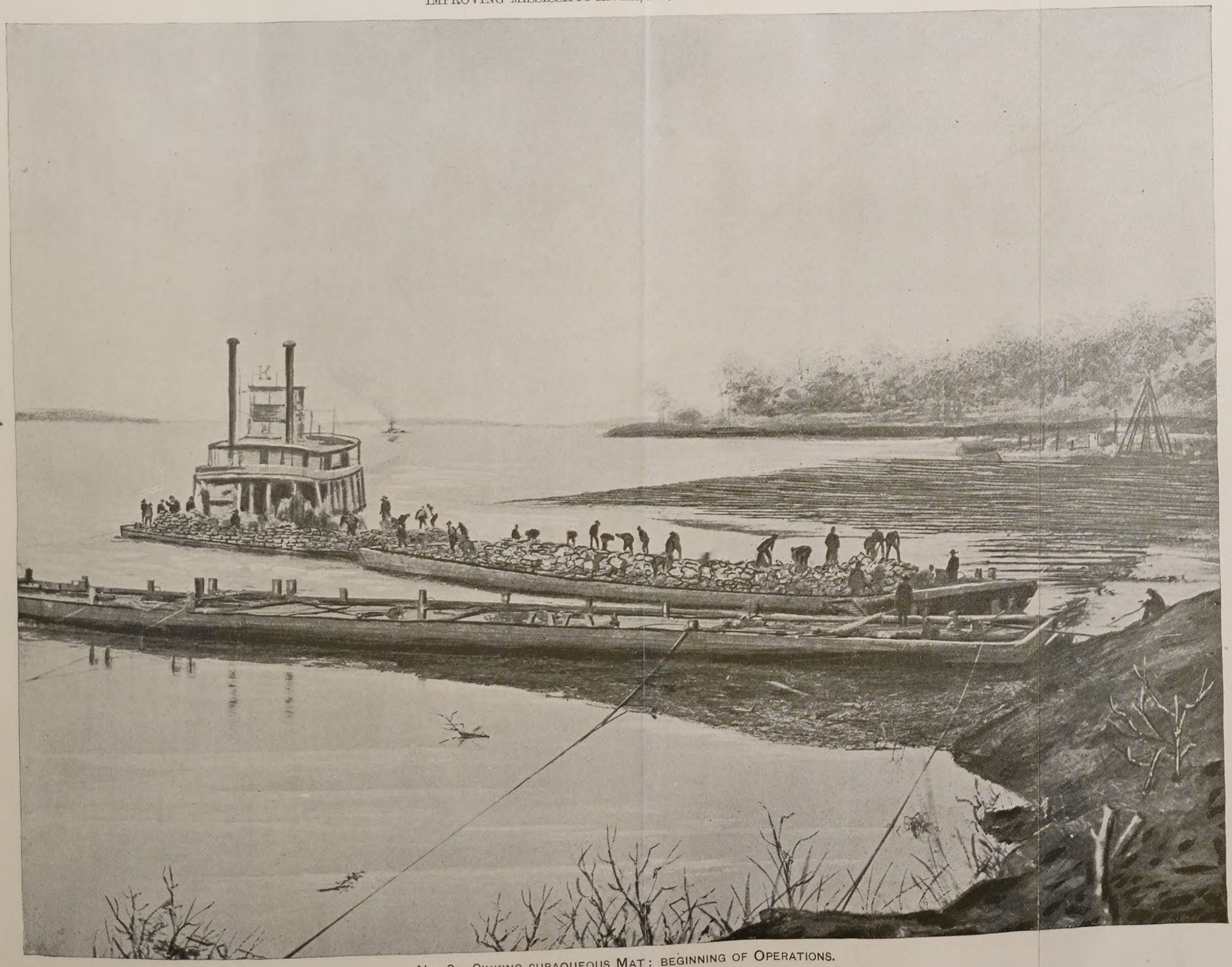


No. 7. Ballasting subaqueous Mat.

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.

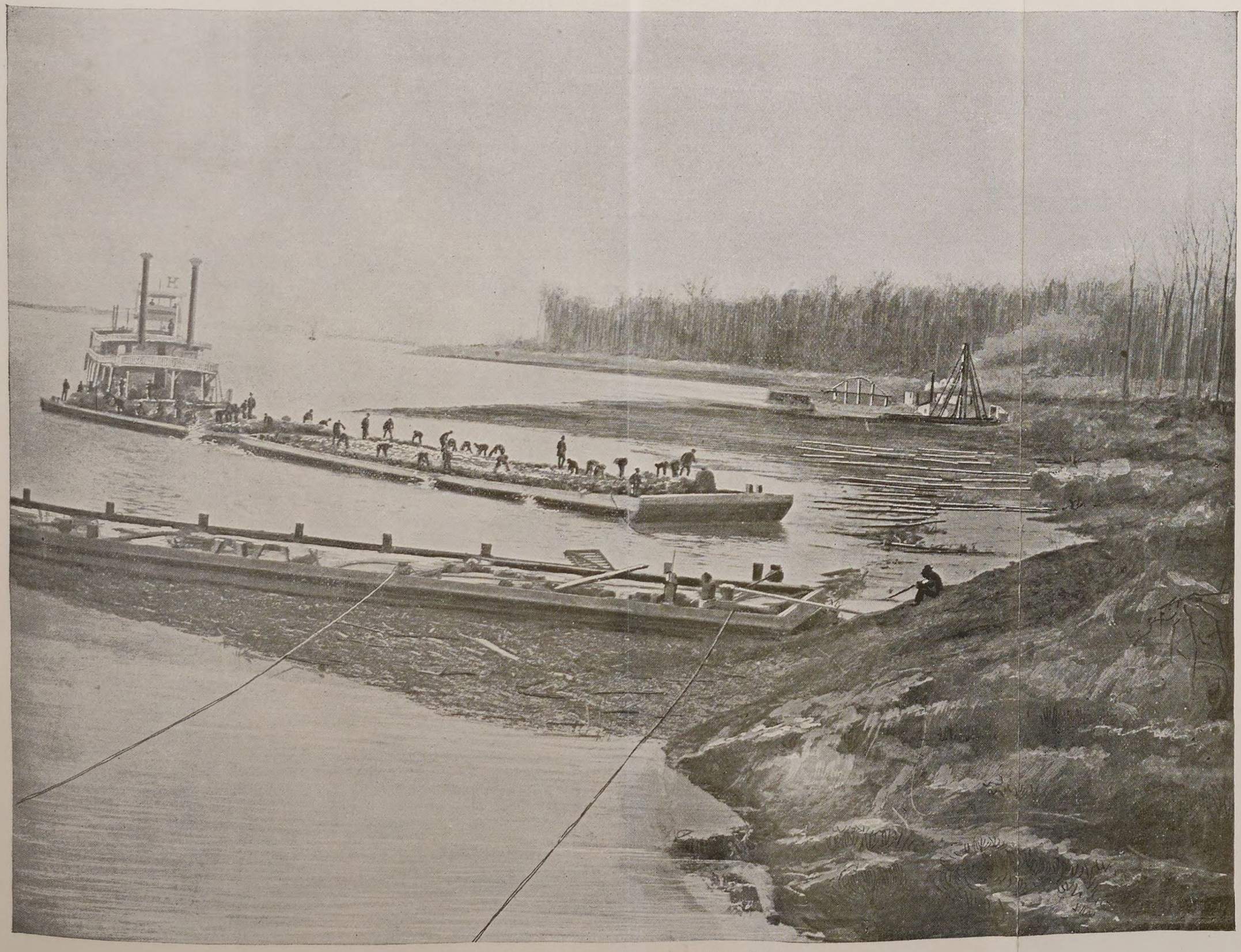


No. 8. General View of subaqueous Mat.



No. 9. SINKING SUBAQUEOUS MAT: BEGINNING OF OPERATIONS.

14



No. 10. Sinking subaqueous Mat: second Stage.

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.



No. 11. SINKING SUBAQUEOUS MAT: ABOUT HALF DOWN.

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.



No. 12. Sinking subaqueous Mat: Close of the Operation.

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.



No. 13. Upper Bank Revetment in Progress

Ill 5

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH..



No. 14. Weaving connecting Mat. Front View.



No. 15. CONNECTING MAT READY FOR LAUNCHING. END VIEW.

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.



No. 16. VIEW OF COMPLETED REVETMENT; RIVER AT ABOUT MID-STAGE.

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.



No. 17. VIEW OF EXPERIMENTAL SECTION, WITH BRUSH-WORK OMITTED ABOVE WATER, THE STONE BEING LAID TEN INCHES THICK. AT THE TIME THE WORK WAS DONE THE WATER STOOD AT UPPER EDGE OF BRUSH.

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.



No. 18. View of Revetment finished in January, 1885.

IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.



No. 19. Building Foot-mat for Dike on dry Bar.



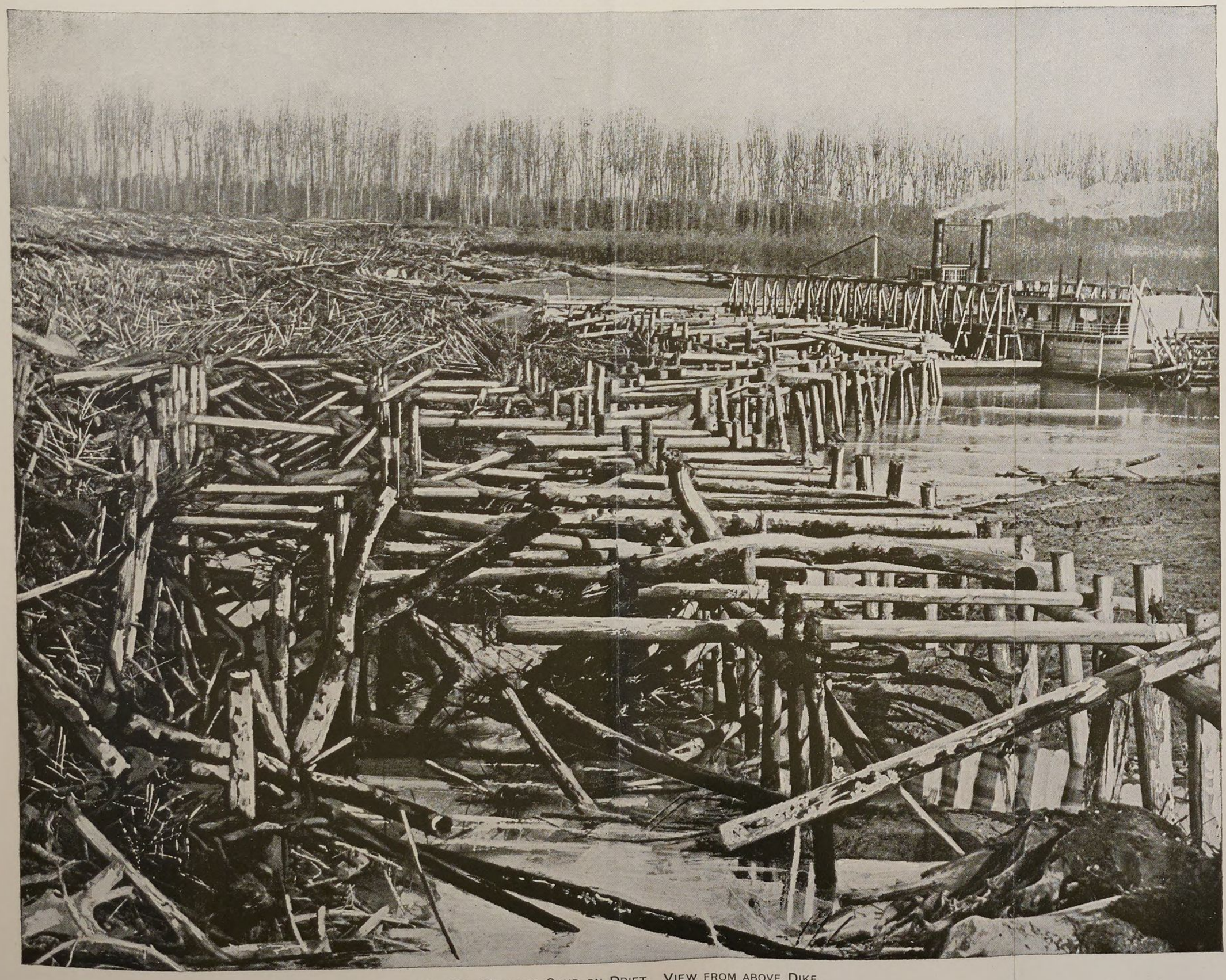
No. 20. View of Mat built afloat and afterward exposed by falling River.

25



No. 21. Sinking Drift above Bullerton Dike by pumping Sand upon it.

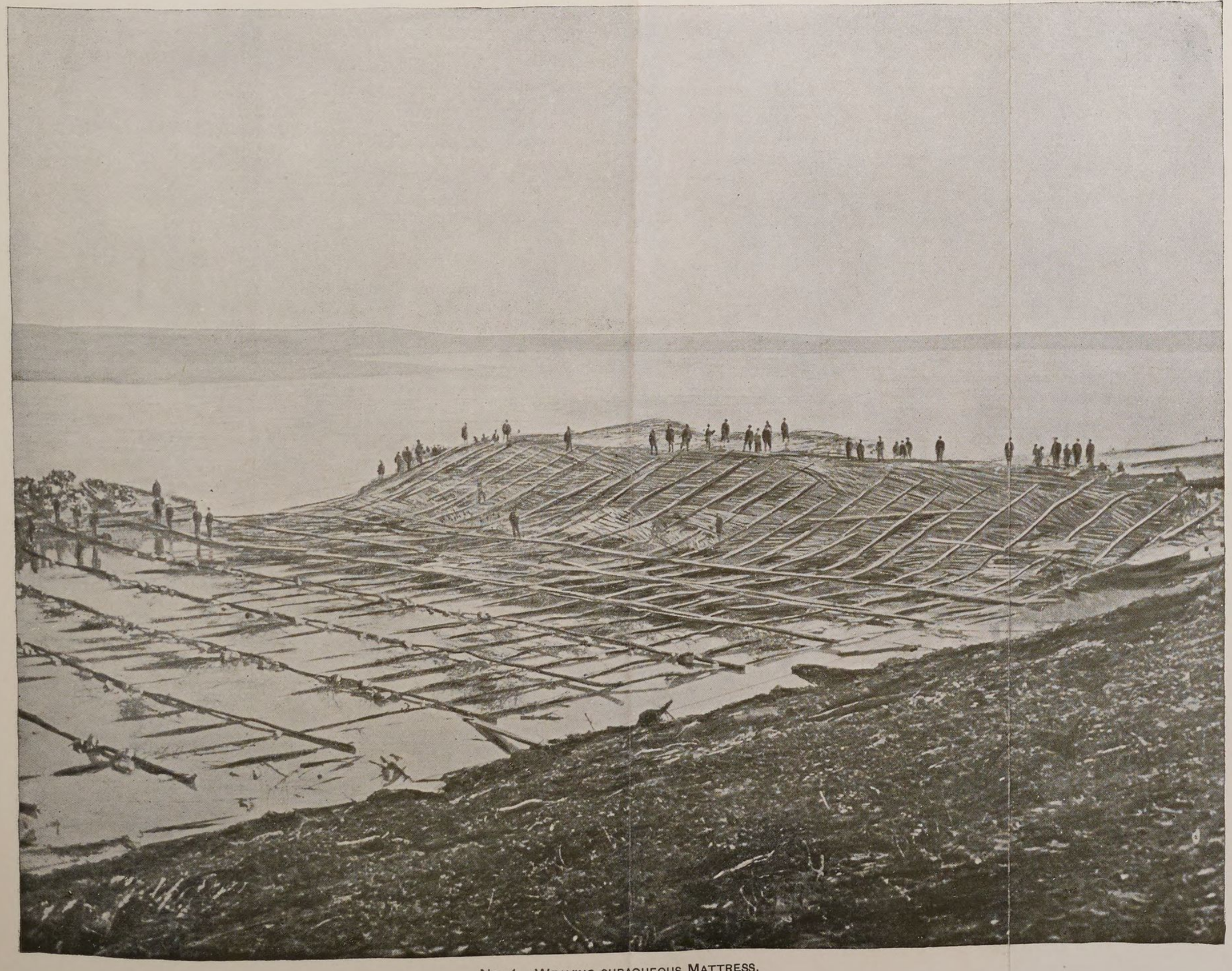
IMPROVING MISSISSIPPI RIVER, PLUM POINT REACH.



No. 22. Pumping Sand on Drift. View from above Dike.



No. 23. Present Appearance of Dike No. 5, Plum Point System, completed in January, 1885.



No. 1. WEAVING SUBAQUEOUS MATTRESS.

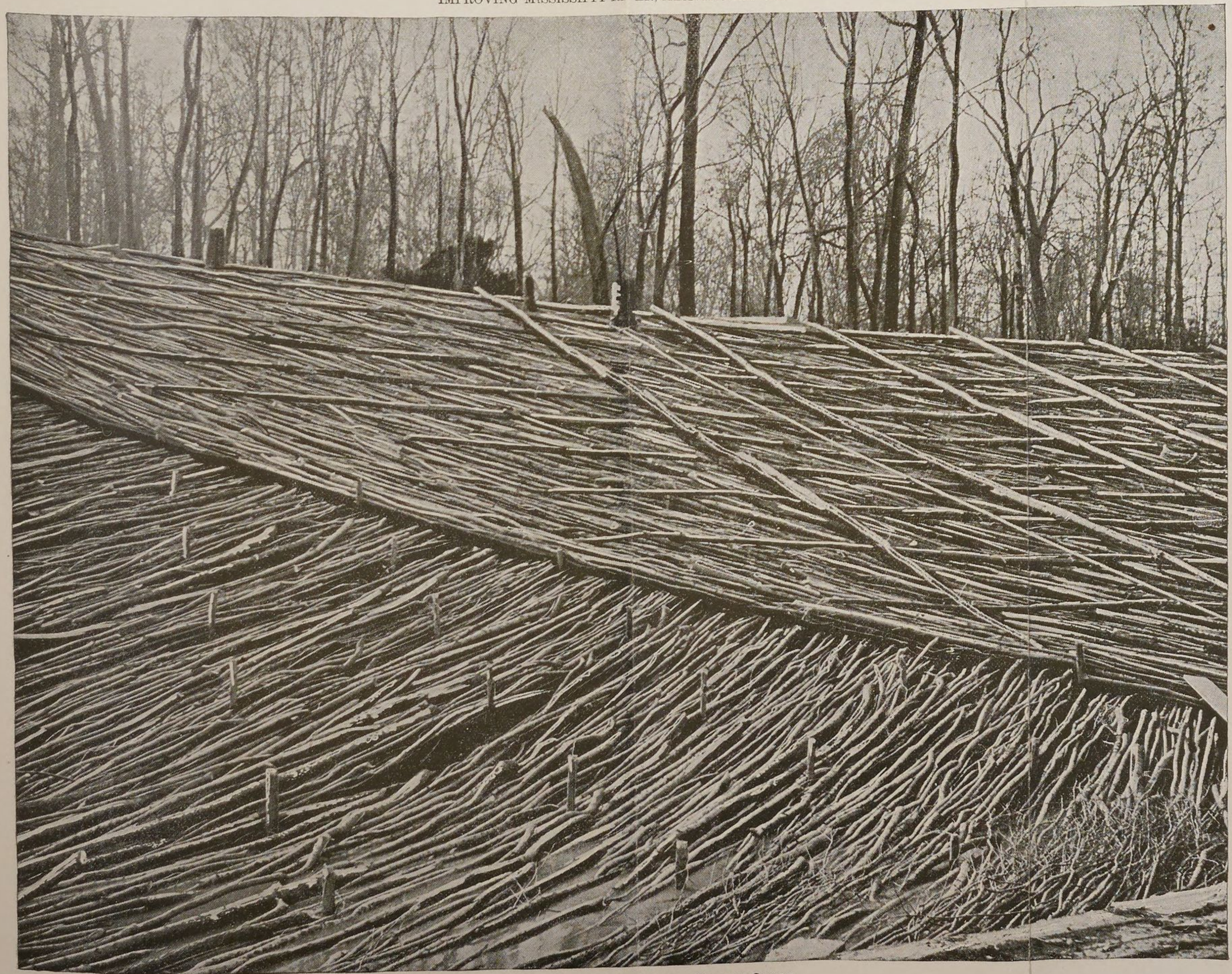


No. 2. Mooring Barges and subaqueous Mattress ballasted.

IMPROVING MISSISSIPPI RIVER, MEMPHIS REACH.



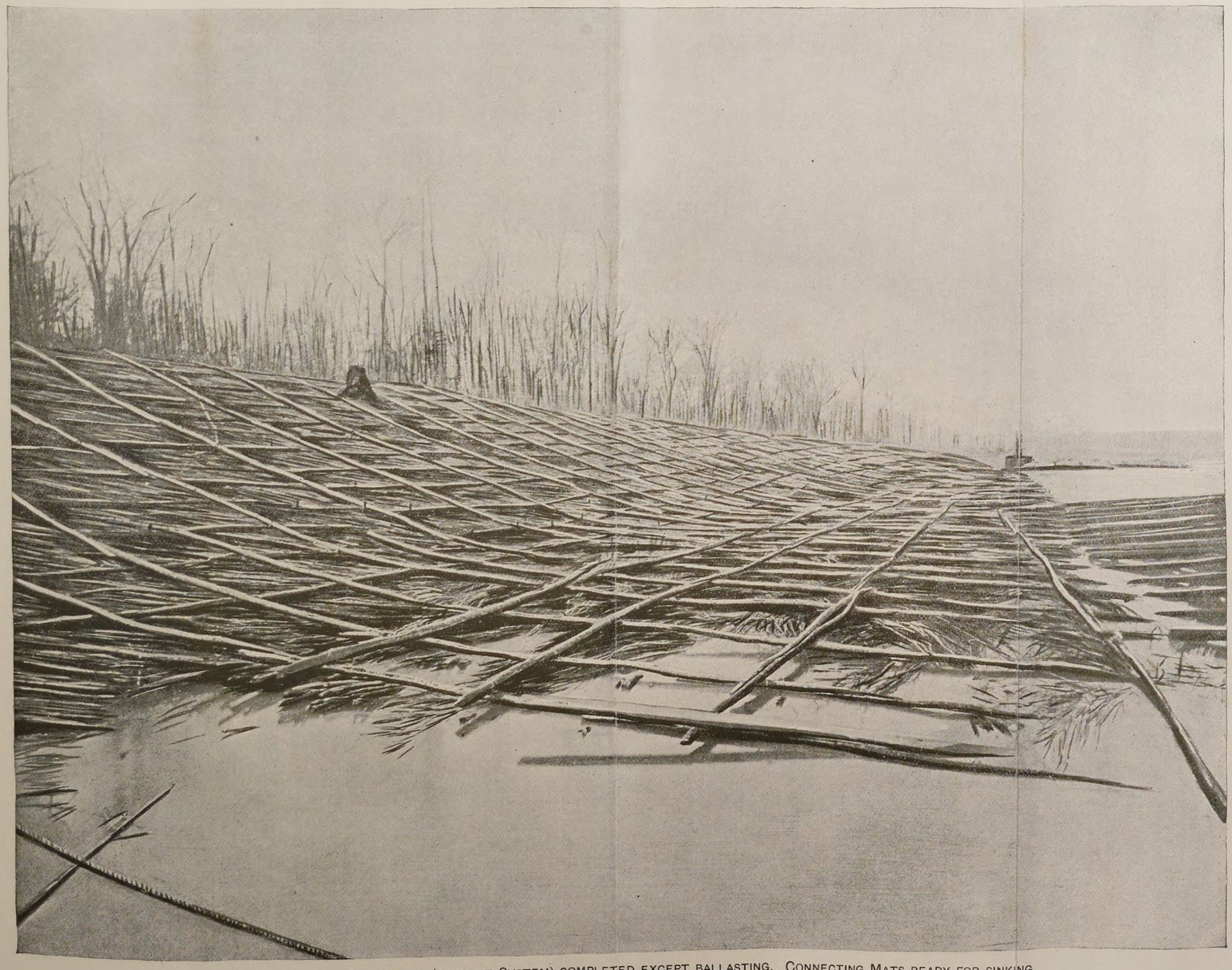
No. 3. Upper Bank Revetment. First Stage.



No. 4. Upper Bank Revetment. Second Stage.



No. 5. Upper Bank Revetment (old Style) completed except ballasting.



No. 6. Upper Bank Revetment (present System) completed except ballasting. Connecting Mats ready for sinking.

The crossings forming group 1 of the table may be considered as competitors for the channel over Bullerton Bar. Bullerton Channel has remained partly obstructed by the diverting action of the works favoring the first channel, which latter has remained good by reason of carrying the water diverted from the other. The two channels of the second group are also competitors, of which the second has been restricted by the direct action of the Fletcher's revetment, and the first, Island 30, has carried the bulk of the water and remained good.

Commerce, trade, manufacture, and navigation of the city of Cairo, Illinois, for the year ending April 30, 1890.

Articles.	Quantity.	Value.	Articles.	Quantity.	Value.
Shipped North by river:	*Tons.*		Shipped South by river:	*Tons.*	
Cotton	14,989	$2,699,110.00	Oats	23,944	$578,890.88
Lumber	31,950	340,909.12	Hay	7,134	92,742.00
Corn	6,404	92,225.88	Bran	4,510	72,160.00
Oats	1,955	39,108.16	Provisions	760	106,505.00
Hay	1,496	17,952.00	Flour	4,172	177,318.50
Merchandise	7,000	1,080,999.00	Corn-meal	5,683	113,676.00
Flour	13,355	567,596.00	Merchandise	2,029	852,138.00
Tobacco	1,350	202,500.00	Lumber	22,050	178,240.00
Fruits and vegetables	5,509	72,229.80	Coal	135,809	271,618.00
Shipped South by river:			Salt	7,590	113,859.00
Wheat	25,473	1,018,950.00			
Corn	20,144	282,019.15	Total	343,306	8,970,737.49

APPENDIX G.

REPORT OF CAPT. S. S. LEACH, CORPS OF ENGINEERS, UPON OPERATIONS IN THE SECOND DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 1, 1890.

GENERAL: I have the honor to submit the following report of operations in the second district under the appropriation for improving Mississippi River, act of August 11, 1888, from May 31, 1889, to May 31, 1890.

The part of the river to which this report relates, known as the second district, extends from the foot of Island 40 to the mouth of White River, a distance of 130 miles.

MEMPHIS HARBOR.

In the last annual report mention was made of a recommendation to the Secretary of War to apply a portion of the balance under this title to converting into permanent structures the parts above low water of the Citizen's dikes, at the lower end of the protected front. This was not included in the original design, as it was hoped that accretions during the life of the brush-cribs would nearly or quite cover and supersede them. This expectation has not been realized, and it having become necessary to strengthen or lose them, the plan of conversion was adopted. The project was duly approved and its execution begun in October, 1889. The main dikes, 2, 3, 4, and 5, were completed before the rising river put a stop to the work. Dike No. 1 required but little and that not of the first importance. It is now entirely masked by earth dumped above it by various parties. Each of the four dikes named was covered with earth, topped with a layer of gravel 1 foot thick and a paving of stone 10 inches thick, the hole so disposed as to have its net crest-line coincident with the crest of the crib-dike when new, with a grass grade higher at all points by one-fifth of the height of fresh earth, and cross profiles of 20-foot crown, 4 to 1 slope down and 2½ to 1 slope up-stream. At the lower end the embankment rested against a toe or abutment of random stone, which was carefully developed without breaking into the paving.

The materials were procured by open-market purchase, the earth at 34½ cents per cubic yard placed in the embankment to lines and grades, the gravel at 30 cents per yard loaded on barges delivered at the work, and the stone at $2 per yard under the same conditions. The gravel and stone were placed by hired labor. Some stone in addition to first estimates was required by reason of the sliding and sinking of the riprap abutments. It was obtained from the reserve stock of the Hopefield revetment, and was handled by hired labor. Besides the trouble with the abutments, work was retarded and made more costly by the stage of the river which, after a few days at low stage, began rising rapidly, making it necessary to transfer men and material from one dike to another with great frequency to keep ahead of the water.

A tabulated exhibit herewith shows the cost of this work in detail.

In the last Annual Report attention was invited to the growth of the bar in the upper part of this harbor caused by the recession of Hopefield Point, and the main features of a plan to remedy the difficulty, should a remedy be demanded, were suggested. During the last low water access to the Memphis levee above the elevator was entirely cut off. The coal fleet was obliged to move across the river and the incline of the Little Rock and Memphis Railroad was cut off. The railroad at considerable cost and trouble found a temporary relief by dredging a narrow cut through the bar opposite the mouth of Wolf River. In view of this evident necessity for action the plan mentioned was taken up and elaborated in sufficient detail and was submitted to the Commission on December 10, 1889. It was found advisable to leave Frame's Chute out of consideration and depend entirely upon Wolf River, augmented by a controllable outlet from the Mississippi at Sycamore Slough.

Recent surveys show a gradual increase of the bar, both in area and elevation. At next low water approach to the Anchor Line Elevator will be obstructed, if not completely shut off. There is no case of obstructed navigation in the district which compares in urgency with this. The estimated cost of the project submitted is $37,000.

The only injury to works in the Memphis reach during the late flood is a fault 500 feet long in the Hopefield Revetment at the lower end of the work of 1887. The upper work only is involved, and repairs will be made during the coming season.

HELENA HARBOR.

The act of August 11, 1888, contained an appropriation of $75,000 for work at this place. A project submitted was approved by the Commission November 30, and by the Secretary of War December 20, 1888. The supply of plant being inadequate to carry on simultaneously all the work in the district, this was postponed until the season of 1889–'90.

The project provided for a protection covering about 3,000 feet of bank, consisting of a continuous revetment of 600 feet from the upper side of the elevator down, and of five spur-dikes, the first 1,100 and the fifth at 2,875 feet from the same initial point. In addition a canal was proposed draining a swamp behind the levee, which had apparently, by supplying seepage water, greatly accelerated the rate of caving. The canal was laid out and excavated during the last fiscal year, though completed at such a late date that its entire cost, $3,195.32, could not be then reported.

Plant and materials were on the ground and operations on the elevator mattress begun on the 26th of August, 1889, the river being at a 12-foot stage and falling. This early date was selected in order to get that mattress down before the cotton movement set in, as all river business at this port is transacted on the site of that mat. This object was further favored by the fact that the crop was ten days late. The mat was sunk on the 3d of September. It is 228 feet wide and 613 feet long. As no upper work was needed, the ground was at once vacated and no material interference with traffic resulted.

Work on Dike No. 1 was at once begun. The foundation or floor mattress, 325 feet wide by 198 long, was completed ready for sinking on the 10th of September. In the afternoon of that day, while attempting to sink it, it tore loose from its fastenings and was a total loss. The immediate cause of the accident was the breaking of a timber-head on one of the mooring-barges. This timber-head held the lashings from that barge to the next one, and when it broke the mooring plant collapsed, driving the mat against the bank and throwing such unequal strains on the lines that they tore loose one by one, and the mat, in a broken condition, went adrift. With proper manipulation this accident should not have occurred, as no strain should have come on the particular lashing which let go. The real cause of the loss was the inexperience of the entire force, and especially of the line foreman, who failed to get the proper distribution of load on the several lines before sinking.

By an unprecedented fatality a second mat was lost on the same site on the 17th of September. The second loss was due to heavy accumulation of drift, and not to any fault in handling the mat. A large mass of drift had collected under the head of the mat. This is not an unusual occurrence, and caused no especial apprehension. Enough rock was placed on the mat just over it to reduce its buoyancy, the rest was ballasted as usual, and the sinking began. Soon the drift shifted its position, and its upward thrust under a different part of the mat, assisted by the then unsupported weight of the extra rock in the place where it had been, tore the mat in two and caused it to break loose.

From this time to the close of the working season there was a constant struggle against strong currents and heavy drift. No such season has ever before been encountered. At times, when work at Plum Point was proceeding without interference from drift, and when none could be seen passing Memphis, large trees by the score were lodging against the plant and under the mats at Helena. Some of them came out of St. Francis, which was at a fair stage most of the time, and some from caving banks below Memphis. Against these difficulties, increased by the rise in the river,

SCALE OF MAP-1:30000

Note: Soundings are given as observed in March, 1888. Helena Gauge reading 24.8 ft.



MISSISSIPPI RIVER COMMISSION

MAP OF
HELENA HARBOR

showing location, plan and sections of

CRIB DIKES

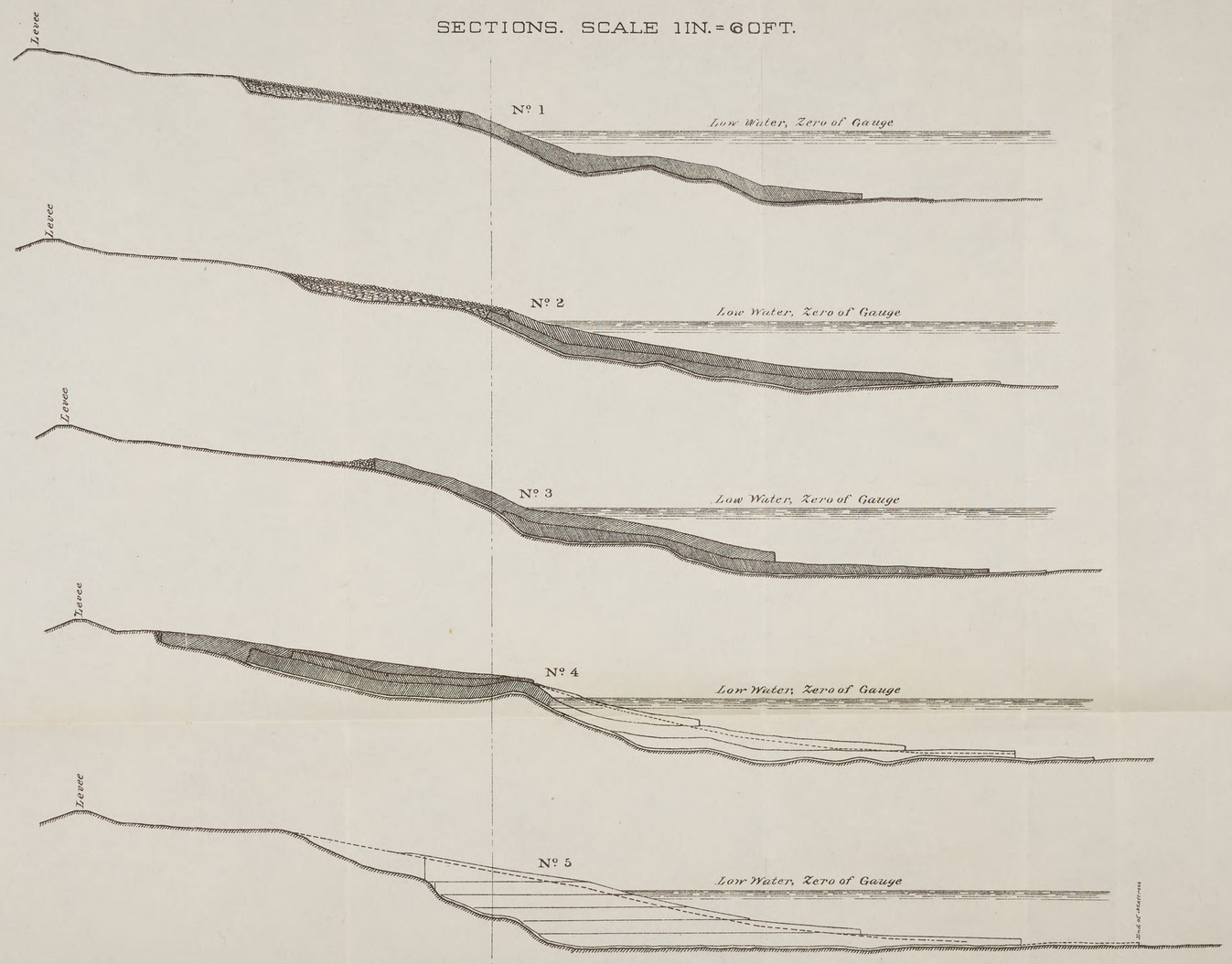
built under the direction of

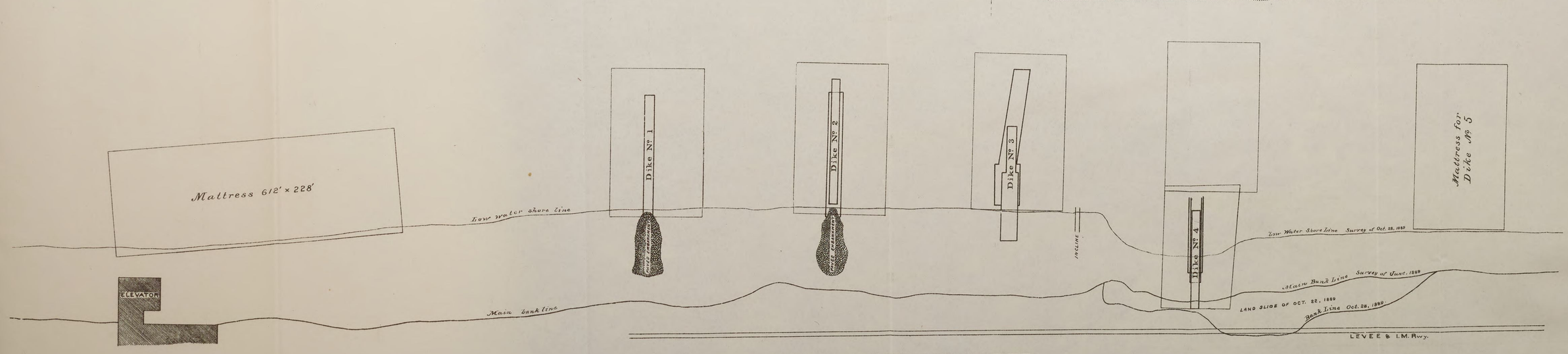
Capt. SMITH S. LEACH,
Corps of Engrs U.S.A.
By
W.M. REES, Asst. Engr.
1889 – 1890

To accompany annual report dated June 1st 1890

Smith S. Leach
Captain of Engineers

SECTIONS. SCALE 1IN. = 6OFT.





PLAN. SCALE 1IN. = 150 FT.

which cut the season in two, and when work had to be suspended, while expenses could not be, but an indifferent showing could be made, and at the end the exhaustion of funds found the project not completed.

A third floor-mat at the site of Dike No. 1 was completed and successfully sunk on September 24. The single crib forming this dike was at once begun and was sunk on the 30th, completing the subaqueous portion of Dike No. 1. The crib is 20 feet wide, 250 feet long, and varies in height from 6 to 12 feet, to bring its top on the required crest line. During the first half of October the subaqueous part of Dike No. 2 was completed, consisting of floor-mat 200 by 330 feet, and two cribs, one 260 by 30 by 8 feet, and one 275 by 18 by 6 feet. In the last half of the same month the floor-mats of Dikes 3, 4, and 5 were laid, as the stage of river was favorable for that part of the work.

On October 15 a slide in the bank occurred, exactly on the line of No. 4 dike. A few days later it extended down stream to the axis of No. 5. It made necessary a modification of the plan of No. 4 by extending the floor mat and cribs inshore to the edge of the slip, to protect the disintegrated earth and fill out the profile of the dike. This change increased the cost of the dike and helped to create the deficit.

By the middle of November Crib 1 of Dike 3 was in place and Crib 2 of same dike and Crib 1 of Dike 4 were partly built. The river had reached a 16-foot stage and was rising fast, making further operations on the river impossible and limiting them to the shore end of No. 4 and embankments of 1, 2, and 3. These parts of the work were finished by the end of November and operations entirely suspended to await the decline of the river. The high stage continued during December, and when early in January the falling river reached a stage at which operations could be resumed, it almost immediately began to rise. The partly finished second crib of Dike 3 was completed and sunk on January 13, and operations were then discontinued.

The portion of the dikes completed and that remaining to be done are shown on the map of the locality herewith.

The magnitude of the difficulties encountered during this season and relied upon to excuse the failure to complete the project within the estimated cost may be better appreciated by the consideration of some administrative details. The expenditures for administration and care of plant were greater by $3,000 than they should have been on the basis of the percentages realized in the case of the Memphis dikes, the only similar work available for comparison. This represents a part of the direct loss from the interruption of work by high water. A similar comparison gives an excess of $1,000, under the head of general repairs, a sum which represents the unusual breakage and other damage due to the excessive strain to which the whole plant was subjected. At the beginning of the season cordage was supplied sufficient in quantity for all requirements, as estimated from previous experience. Before the close it had been necessary to supply over $2,000 worth in addition to meet the losses by breakage and to provide the extra strength which was plainly required. Each dollar of this represents another one, and perhaps more, involved in delays and the handling and rehandling of the extra lines. All this is in addition to the value of the two mats lost, say $5,000, a sum which alone exhausts the percentage usually estimated for contingencies. Even with this loss, under the most unfavorable conditions encountered elsewhere in the experience of the present writer, the project could have been completed with the funds available.

The financial statement and other exhibits herewith show in detail the cost of the work done and the balance of the appropriation remaining on hand. The latter consists exclusively of materials for construction, purchases in the principal lines having been made at the beginning of the season and for the full amounts of the estimates. Based on the known quantity of work to be done and the known cost of that already done, with allowance for the increased expense due to a mobilization of plant for such a small expenditure, it is estimated that an additional sum of $15,000 will be necessary to the completion of the project, and it is recommended that the sum named be provided by allotment if it should not have been done by appropriation.

DETAILS OF CONSTRUCTION.

Under the present appropriation there have been constructed in the first and second districts, since September, 1888, over 4½ miles of subaqueous mattress of all kinds, of which 3¾ miles have formed part of completed standard revetment. This has been in fact the first period of genuine activity since the beginning of 1885. Its experiences have contributed greatly to the development of a satisfactory type of continuous revetment, the fundamental requirements of which are now clearly seen and its principal lines of future improvement strongly indicated.

The matter of first importance is a sufficient width of subaqueous mattress, for if that be undetermined the revetment may be carried out bodily, or so broken up, both below and above the water, as to lose its resisting power. It is manifestly desirable that the outer edge of the mat should reach to or beyond the *thalweg*, and in most

cases of banks needing protection it can be so arranged. It happens that the width from low-water line required to do this seldom falls enough below 200 feet to offset the advantages of uniformity in that regard, and that width may now be accepted as a minimum for the upper part of the river. From this minimum the width may be increased as seems necessary. It will be better to keep the inside edge at low water and weave a mat of the desired width. Should the available mooring and weaving plant lack something of this width, the inside edge may be held out 25 or 30 feet and the connection extended to join it. This was done at Daniel's Point, when, with only 200 feet of mooring and weaving barges, the outer edge of the subaqueous mat was left 225 feet from low water. A braced bent of piles should always be driven to take the thrust of the mooring-barges, and a line of single piles 50 feet apart along the inside edge of the mat is a great convenience in weaving and sinking. All these piles should be pulled before the work closes, or, if that is too difficult, they should be cut off at the level of the mat. If left they are most dangerous obstructions.

It is in the construction and sinking of the subaqueous mattress that occur all the critical situations, interruptions, disasters, and losses, which, though constantly decreasing with added skill and experience, have up to the present time made the cost of such work sometimes excessive and always uncertain. They have hampered the administration of the work by making it impossible to foresee when operations could be commenced or how long they might be prosecuted. They have originated almost exclusively in two causes—the presence of drift and the inefficiency of the fastenings relied upon to hold the plant in position. These fastenings have consisted of manilla head and shackle lines, the former fastened to timber-heads on the mooring-barges and the latter to straps built into the mat-head, and all led obliquely to fixed points on the bank. These large lines sagging into the water are swept by the current out of vertical planes and assume positions represented by the dotted lines on the accompanying sketch (Fig. 1). The efficiency of each line in its actual position is the same as that of a straight line having the direction of a tangent at the point of attachment to the mooring-barge. Drift lodging against the lines increases the displacement, which has the additional disadvantage of being at a maximum on the outside lines, which should be the most secure. The greatest trouble caused by drift is during the sinking. When a quantity has passed under the mooring-barges and lodged under the mat, as is usually the case, its buoyancy must be counteracted by an excess of rock placed on the mat immediately over it. The composite mass of wood and stone is in unstable equilibrium during sinking, save from the resistance of the mat to flexure. The impact of current may overcome this and cause the drift to move, when, its upward thrust and the weight of the rock no longer counterbalancing each other, the mat is torn across and partly or wholly lost. Several plans for keeping the plant clear of drift have been discussed, and on one or two occasions loaded barges have been strung along the outside line to form a sheer boom. Such devices are only partially successful, for some pieces will strike and dive under and others are water-logged and float so low that they miss the boom. It has been discovered that all the drift that can lodge in front of the mooring-barges does not cause a great strain and it has been proposed to throw out fender-barges above the mooring-barges and hang festoons of chains from them in such a way as to catch the drift and hold it until the accumulation suffices to form a natural boom. This plan was tried at Helena near the close of the season and the report upon it is sufficiently favorable to warrant its further use. The disposition of the barges and chains is shown in a sketch submitted herewith (Fig. 2). It has the additional advantage of providing a basis for an improved system of fastenings, consisting of steel cables running parallel to the current, as shown. On the map of Hickman Harbor, herewith, is shown a method of fastenings used there and with some modifications at Columbus. It meets that problem fully, but does not provide against drift. On the last mat at Daniel's Point a set of steel shackle-lines was substituted for the manilla ones, with such manifest advantage as to make it certain that the strong predilection heretofore existing in favor of manilla is baseless, and that that costly item of equipment may be greatly reduced. All head and shackle lines may be of metal with great increase of efficiency and saving of cost.

The method of connection between the sub-aqueous and shore-mats, introduced during the past year, in addition to its other advantages, contributes greatly to the ease and certainty of the difficult operation of sinking. It will be remembered that formerly the river-mat was laid with its inner edge at about the low-water line. Next the shore work was placed, extending down the slope to the actual water line at the time. The strip of bank between these lines was then covered by connecting mats. At the time of sinking, the river-mat was entirely free except at its head and except also, that cables were laid to prevent its moving out towards the river. The cables rarely had anything to do, for the tendency was usually to creep up the bank toward the foot, probably due to the greater strength of current on the outside, which took all slack out of the cables and lashings and lengthened the outer edge of the mat. By

Fig. 1.

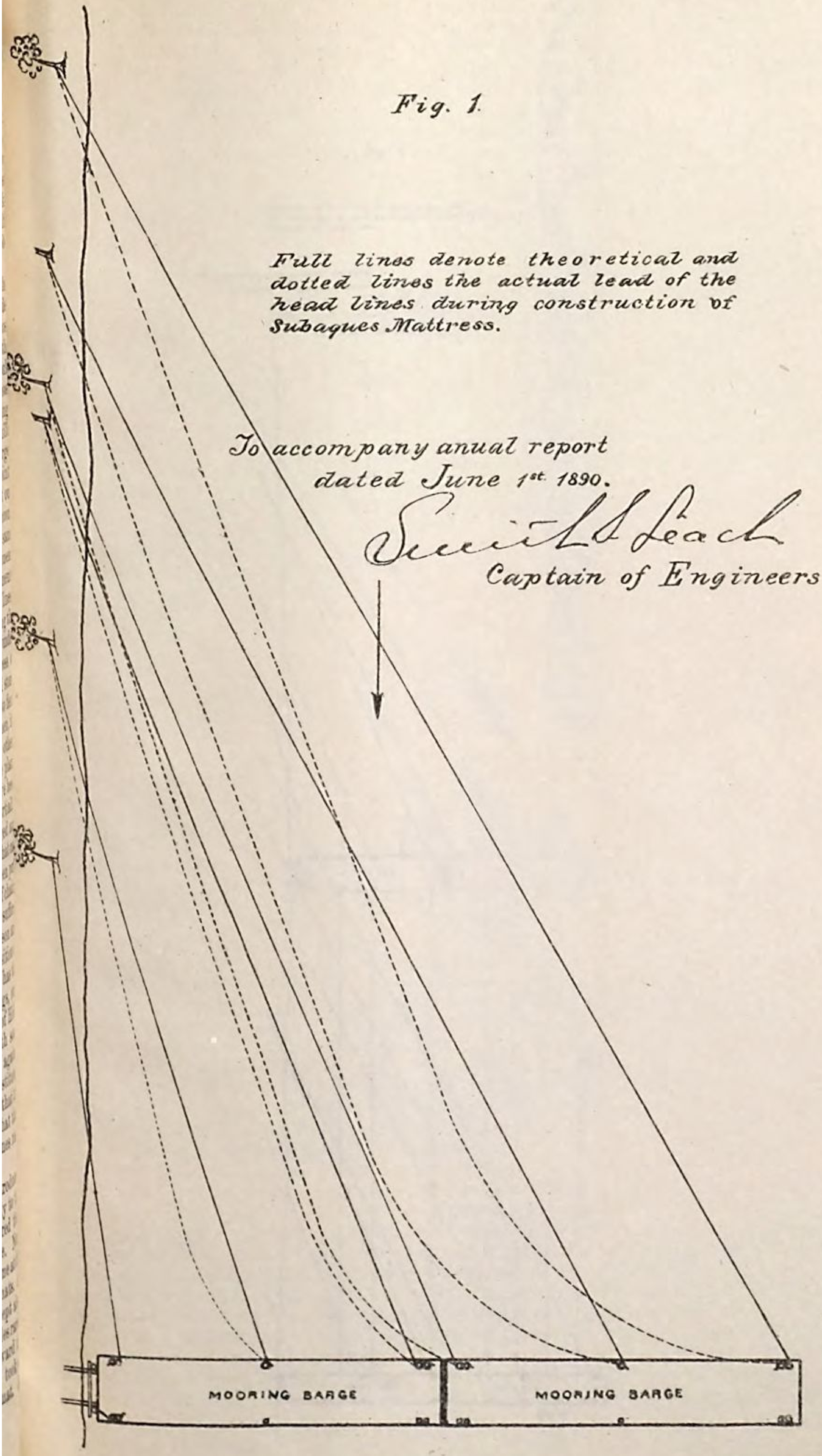
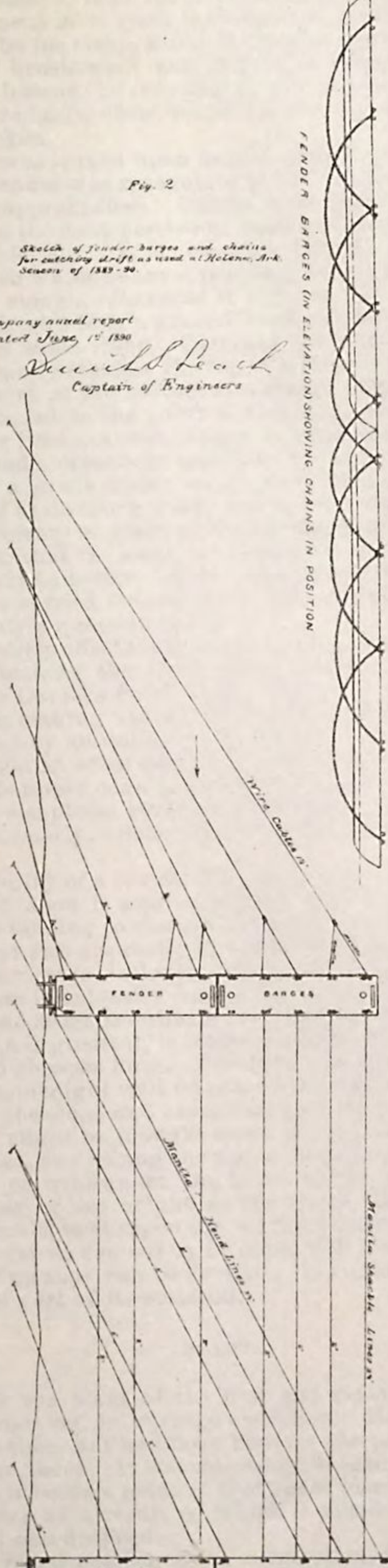

Full lines denote theoretical and dotted lines the actual lead of the head lines during construction of Subaques Mattress.
To accompany anual report
dated June 1st. 1890.
Captain of Engineers
MOORING BARGE
MOORING BARGE

Fig. 2

Sketch of fender barges and chains for catching drift as used at Helena, Ark. Season of 1889-90.

To accompany annual report dated June 1st 1890

Daniel L. Leach
Captain of Engineers



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the method now in use, the connection is made before sinking, and its full strength is available during that process to hold the inner edge of the mat in position.

A second vital requirement of a good revetment is a sufficiently flat grade above low water. If the slope be too steep, slides or sloughs will occur, each displacing the corresponding portion of brush-work and tearing it loose from the adjacent parts. Breaking the continuity lessens the resisting power of the revetment, since the torn edges are attacked and gradually destroyed under conditions which are not present so long as the bond is unbroken.

At first this sloughing was looked upon as something mysterious and was dreaded accordingly. Later, its cause was recognized in the efflux of ground water, but even then its nature was misapprehended. Efforts were made to meet the difficulty by drains and buttresses and the most persistent cases met with were conquered by these means, but at considerable cost. It is now seen that the natural bank graded to a slope and surcharged with water behaves precisely as any other earther slope would do. If too steep it will slough, otherwise it will not. If a levee or other artificial embankment will slough at 3 to 1, a graded bank of the same material can not be expected to stand at the same slope. Carrying the analogy further, it may be observed that sloughing rarely reaches the top of a levee and never begins there. A banquette or other support at the bottom of a slough stops it by raising the foot of the slope until it is flattened to the point of stability, while above the slough, the original slope remains, or becomes even steeper in some cases. The evident necessity of a flat and regular grade, especially near low water, points to the desirability of means for making such a grade under water, since in most years the extreme low-water season is too brief to do much work, and in some that stage is not reached at all. It will often be necessary to grade at higher stages and when it is so, it is essential to really good work, that the slope be continued under water to extreme low water, and further, would be better. Some experiments in this direction have been made, but have not been carried far enough to give definite indications. Of course it can be done. It is only a question of cost.

It may be possible to partly offset the increased cost due to increased width of shore-work on a flat slope by making the upper third steeper. This was tried on a small scale at the head of the Daniel's Point work, where the lower slope of 4 to 1 was changed to 3 to 1 above, making the entire width of shore-work 10 feet less than would have been required by an uniform 4 to 1 slope.

In still another direction an effort has been made to narrow the shore work by terminating the grade at its upper edge in a vertical bench of such height as to bring the upper surface of the completed revetment tangent to the top of the bank, instead of the lower surface as formerly. Some further retrenchment in this direction seems feasible.

The real source of stability of a revetted upper bank is in the flat slope given to it. The protective work laid upon it acts only indirectly by preserving the slope from abrasion. The agencies tending to disturb the grade are wave and water-line action and rain wash. The first two are really the same, the abrasion so often observed at the water-line when the river is stationary being caused by minute waves. All these disturbing forces decrease in intensity from extreme low water up, and since the present covering of brush and stone is uniform in strength and is quite sufficient at the bottom where the strain is greatest, it seems probable that it may be replaced near the top by a lighter and cheaper form. Bermuda sod and willow plantations seem most likely to succeed and might well be introduced experimentally in future work, beginning at the top of the slope and extending gradually downward. It is possible that in some cases they might be brought down to the line of continuous vegetation. All the methods indicated, steepening the upper slope and covering to the top with brush, substituting sod or willows for the brush on the upper slope, and leaving a vertical bench of greater or less height at the top of the slope, may be utilized on banks of different materials, to cheapen the work by narrowing the brush covering, which, when carried as far as can safely be done, will give the cheapest efficient protection from low water up that can be devised. It is open to a single objection in the perishable nature of part of its material.

PLANT.

During the past year the plant of the first and second districts has decreased in amount, but is much improved in average condition. Many pieces had been wholly unserviceable for sometime, but had been kept on the papers in the hope that some use might be found for them. It was necessary to remove the fleet from Bullerton Chute, and in doing so it become evident that these pieces could not be moved. An inspection was asked for, as a result of which 9 pile-drivers and 78 miscellaneous pieces were condemned and dropped.

One of the earliest recommendations in connection with the last appropriation, was the construction of a floating dock. It was completed in January, 1889, and has

since been in constant operation. Most of the heavy pieces have been docked and repaired as thoroughly as their condition would justify. By the time another appropriation is available everything except barges will have been on the dock.

In the classes of steam-boats, graders, pile-drivers, quarter-boats and weaving barges, the present plant with slight current repairs should suffice for the expenditure of any allotments likely to be made to the two districts for the next two years. But one set of mooring plant can possibly be used again and that would scarcely be safe under a great strain. These barges, to meet all demands upon them, must endure a variety of strains, both in direction and intensity such as was never contemplated in the present type of barge construction and which no structure in wood, of reasonable cost can stand for any length of time. In substituting wire for manilla-rope in the head lines, the elasticity of the former, which tends in a measure to equalize these strains, is lost. Under the new conditions it is not advisable to build mooring barges of anything but steel, and they should be provided with mechanical appliances for handling the wire cables. They can be used for mooring barges in the present way or as fender barges, should that plan be adopted. In the latter case the strains on the mooring barges will be lessened and some of the present barges will answer.

The number of barges now fit for use is entirely insufficient to carry on operations of any magnitude. The work of the last two seasons would have been impossible but for the general service barges, which the early delivery of the stone made available for use in the districts. Some of these barges are scarcely fit for loading with stone, while amply strong to carry brush. Those, it is probable, will be left to the districts, but even with them there will not be enough, as scarcely a single one of the district barges is fit to load to its full capacity. The demand for riprap stone in large quantities which the works have made for several years past has brought forward a number of quarry owners, steam-boat men and contractors who have offered and delivered stone at various points, and in almost every case at less cost than it could be done by the general service plant. More than half of the stone used under the last appropriation was obtained by contract or by open purchase of outside parties. Of course the knowledge on the part of these people that the Government has the plant ready for use, is an important factor in the maintenance of low prices. It would not be prudent, therefore, to dispense with the plant, but as its use for towing stone will be much less frequent than formerly, it should be divided among the districts, where it can always be used to advantage, when work is in progress and at other times, can be cared for in connection with the local fleets at less cost than as a separate organization.

THE FLOOD OF 1890.

A stage of 40 feet on the Cairo gauge may be taken as the point at which the river in that vicinity ceases to be channel-contained and overflow conditions begin. In 1890 the river at Cairo was above that stage from January 16 to February 1, February 13-20, and February 27 to April 15, a total of seventy-one days. In 1882, the year of the only flood with which this one is comparable the 40-foot stage was passed in ascending on January 15, and in descending April 3, giving a flood period of seventy-eight days as compared with the seventy-one days of the flood of 1890. The relative heights of the latter with respect to 1882 and also to the highest known water at various points in the first and second districts are shown in the following table:

High-water table.

Station.	Distance from Cairo.	Highest known water.		Highest water, 1890.		1890, above or below highest known.	1890, above or below *1882.*
		Date.	Gauge.	Date.	Gauge.		
			Feet.		*Feet.*	*Feet.*	*Feet.*
Cairo, Ills	0	Feb. 27, 1883	52.17	Mar. 12	48.80	—3.37	—3.07
Belmont, Mo	21	Feb. 23, 1884	45.80	Apr. 6	43.03	—2.77	—2.47
New Madrid, Mo	69	Feb. 24, 1884	41.52	Mar. 15	38.18	—3.34	—3.09
Cottonwood Point, Mo	123	Feb. 28, 1883	37.85	Mar. 15	36.40	—1.45	—1.15
Fulton, Tenn	175	Mar. 1, 1882	36.69	Mar. 22	34.90	—1.79	—1.79
Memphis, Tenn	232	Mar. 10, 1889	35.30	Mar. 15	35.60	+0.30	+0.40
Mhoen's, Miss	275	Mar. 8, 1883	40.20	Mar. 29	38.50	—1.76	—1.30
Helena, Ark	307	Apr. 30, 1886	48.10	Mar. 29	47.70	—0.40	+0.50
Sunflower, Miss	353	Mar. 10, 1883	41.75	Apr. 1	42.90	+1.15	+1.20

Omitting the record at Memphis, which will be discussed later, it appears from the column of differences that in the first hundred miles below Cairo, the maximum heights of 1890 were 2.77 to 3.37 feet below the highest previously known and 2.47 to 3.09 below those of 1882. In the next 200 miles, the corresponding differences were 1.45 to 1.79 and 1.15 to 1.79 respectively, or roughly, about half of those in the first named section. At Helena the 1890 flood passed above 1882, though still a fraction of a foot below the highest known point, and at Sunflower Landing, 353 miles below Cairo, the flood of 1890 was 1.15 feet the highest on record.

The anomalous elevation at Memphis first appeared in 1886. It is purely local, disappearing a few miles above and below the gauge. Prevailing opinion has assigned as its cause the building of railroad embankments across the St. Francis Basin, of which three are now there, the Kansas City, Little Rock and Iron Mountain. The second of these has been in existence for many years, and can not be used to account for this phenomenon. Advantage was taken of the excellent opportunity offered by the late flood to investigate the effect of these embankments in retarding the swamp wave and returning part of it at and above Memphis. A party was organized and equipped with a leveling apparatus and current meter mounted on a hand car and sent twice over the Kansas City and once over each of the other roads. The relative elevations of water surface above and below the embankment were determined at frequent intervals and the discharge through openings was carefully measured. All the conditions were favorable for close work and the results may be confidently accepted. They are shown in the following table:

St. Francis Basin.

Station.	Date.	Gauge, Memphis.	Area.	Mean velocity feet per second.	Discharge, cubic feet per second.
			Sq. feet.		
Kansas City, Springfield and Memphis Rwy.	Mar. 17, 18, 19	35.60	264,994	1.84	487,536
Do	Mar. 28, 29	35.50	274,020	1.77	484,111
St. Louis, Iron Mountain and Southern Railway	Mar. 21, 22	35.40	498,250	1.16	578,817
Little Rock and Memphis Railway	Apr. 1, 3	35.40	229,551	2.18	501,225

The volume of the swamp wave is shown to have been, in round numbers, 500,000 cubic feet per second. Three of the determinations agree very closely. The fourth one, the Iron Mountain road, is larger by some 20 per cent. This is partly accounted for by heavy local rains just preceding the dates of that measurement, and partly by the low velocities encountered, for which the performance of the meter, an old one and much worn, was far less reliable than in the other cases. The superelevations on the upper sides of the embankments averaged 0.86 foot, 0.44 foot and 0.23 foot for the three roads in the order in which the swamp wave passed them. With a volume of swamp wave fully as great as previous experience would lead us to expect for such a flood, and with such slight disturbance of the normal flood surface in the vicinity of the road-beds, it may safely be concluded that they are not responsible for any appreciable part of the recent abnormal flood-heights at Memphis.

But one other cause can be assigned for this phenomenon, and while the effect is surprisingly large, it may be as well to suspect our preconceived ideas of what it ought to be as to reject the apparent demonstration of what it is. That cause is the recent change in the shape of the river immediately above Memphis. Caving in the bend opposite has progressed until the entire stream is now thrown off from Hopefield Point and projected bodily directly toward the gauge. To escape the *cul-de-sac* the river is compelled to turn an angle of more than 90°, and the force to do this must be represented by a local elevation of surface. Add to this the fact that the changes mentioned have had the effect of placing the Memphis gauge a mile or more nearer Cairo relatively than it was before, and it is believed that the superelevation of recent floods is fully explained as a local disturbance which may be neglected in discussing the general flood profile.

The volume of the flood of this year in the channel of the river was well determined by discharge observations at New Madrid, Plum Point, Memphis, and Helena. The results obtained are here tabulated.

Observed flood discharges, 1890.

NEW MADRID, MISSOURI.

Date.	Gauge.	Area.	Mean velocity feet per secood.	Discharge, cubic feet per second.
		Sq. feet.		
Mar. 25	36.6	239,698	5.55	1,329,387
Apr. 8	37.7	246,492	.....	.....
Apr. 10	36.9	240,893	5.29	1,274,319
Apr. 11	36.2	236,028	5.23	1,234,597
Apr. 12	35.6	233,081	5.21	1,214,031
Apr. 14	34.2	226,213	4.75	1,073,506

PLUM POINT REACH.

Location.	Date.	Gauge.	Area.	Mean velocity feet per second.	Discharge, cubic feet per second.
	1890.	*Feet.*	*Sq. feet.*		
Main river	Mar. 7	30.30	144,400	5.28	762,130
Elmot chute	....do ...	30.30	43,980	3.24	142,372
Island 30 chute	....do ...	30.30	33,310	3.39	113,012
Total	.....	.....	221,690	.....	1,017,514
Main river	Mar. 9	30.90	148,720	5.49	816,140
Elmot chute	....do ...	30.90	42,340	3.59	151,824
Island 30 chute	....do ...	30.90	34,564	3.16	109,393
Total	.....	.....	225.624	.....	1,077,357
Main river	Mar. 12	31.66	153,560	5.54	850,348
Elmot chute	....do ...	31.66	45,340	3.57	161,874
Island 30 chute	....do ...	31.66	34,460	3.39	116,868
Total	.....	.....	233,360	.....	1,129,090
Main river	Mar. 15	32.09	152,425	5.76	878,098
Elmot chute	.. do ...	32.09	49,615	3.52	174,689
Island 30 chute	....do ...	32.09	36,836	3.19	117,362
Total	.....	.....	238,876	.....	1,170,139

MEMPHIS, TENNESSEE.

Date.	Gauge.	Area.	Mean velocity feet per second.	Discharge, cubic feet per second.
1890.	*Feet.*	*Sq. feet.*		
Mar. 17	35.60	159,632	8.36	1,335,187
Mar. 18	35.50	154,394	8.24	1,272,922
Mar. 20	35.50	153,526	8.76	1,345,037
Mar. 22	35.65	144,792	8.51	1,232,445
Mar. 24	35.58	151,479	8.69	1,315,857
Mar. 25	35.55	152,037	8.50	1,292,628
Mar. 26	35.46	147,637	8.83	1,295,314
Mar. 27	35.40	147,957	8.54	1,263,565
Mar. 29	35.30	152,232	8.46	1,288,566
Mar. 31	35.30	157,725	8.32	1,312,582
Apr. 1	35.38	145,390	8.29	1,204,949

Observed flood discharge, 1890.—Continued.

HELENA, ARKANSAS.

Date.	Gauge.	Area.	Mean velocity feet per second.	Discharge, cubic feet per second.	Discharge over bank.
1890.	*Feet.*	*Sq. feet.*			
Apr. 3	47.42	242,611	6.38	1,547,348	*37,370
Apr. 4	47.40	246.875	6.36	1,570,004	.....
Apr. 5	47.31	236,125	6.36	1,500,843	.....
Apr. 7	47.16	236,315	6.18	1,460,675	†11,205
Apr. 9	47.05	231,200	6.05	1,398,355	.....
Apr. 10	47.03	238,800	5.98	1,405,100	.....
Apr. 12	47.08	235,565	6.13	1,443,430	.....
Apr. 14	47.20	233,000	6.29	1,466,466	.....
Apr. 16	47.40	237,418	6.23	1,497,360	.....
Apr. 17	47.46	238,220	6.38	1,519,374	.....
Apr. 18	47.31	238,720	6.23	1,487,103	.....
Apr. 19	47.00	228,890	6.43	1,471,400	.....
Apr. 21	46.00	230,840	5.92	1,367,641	.....
Apr. 23	44.48	224,090	5.66	1,269,101	.....

* Austin crevasse. † Louisville, New Orleans and Texas Railway.

From the foregoing data a comparison of the volume of the last flood with that of 1882 at New Madrid 75, Fulton 175, Memphis 232, and Helena 307 miles below Cairo, may be made with a fair degree of satisfaction. At New Madrid the highest observed discharge was 1,329,000 cubic feet per second for a stage of 36.6 preceding the maximum which was 38.18 feet or 1.58 feet above the stage of observation. In 1888–'89 a series of discharges were measured at the same section from which the form of the velocity curve is known. Knowing the rate of increase of both area and velocity, the discharge at the highest stage may be approximately determined from this lower observation and is found to be 1, 412,500 cubic feet per second. The nearest discharge station in 1882 was at Columbus, 55 miles above this. There is no tributary between them and the escape over the west bank is all or nearly all returned at New Madrid. A direct comparison of New Madrid in 1890 with Columbus in 1882 will not introduce serious error. The maximum discharge of 1882 at Columbus was 1,603,000 cubic feet per second, being greater than the New Madrid discharge of this year by 190,500 cubic feet per second or scant 12 per cent., which is the excess in volume of the flood of 1882 over that of 1890 in this vicinity. Any error which may have been introduced by the direct comparison of New Madrid and Columbus, would tend to reduce this percentage of excess, or in other words to make the flood of 1890 appear relatively larger.

The observed discharges at Plum Point were on a section 15 miles above Fulton, where a permanent gauge is maintained and where discharge measurements have been made on several occasions, so that the velocity curve is well known. From the Plum Point section to Fulton there are levees or high ground on both sides of the river except for a distance of 4 miles on the east side, where a small stream known as Cold Creek debouches. This creek is supplied by water escaping from the Mississippi between Ashport and the hills, and which goes around the discharge section at Plum Point. The discharge of Cold Creek has been measured several times and may be safely taken at 25,000 cubic feet per second. Adding this to the maximum observed at Plum Point, 1,160,000, the sum 1,185,000 should be the discharge at Fulton at the same stage, which was 34.53 feet on the Fulton gauge. The maximum reading of this year at Fulton was 34.90, being 0.37 foot above the stage corresponding to this determined discharge. The increase in discharge at this stage is 37,500 cubic feet per second for 1 foot of rise on the gauge, so that 1,200,000 cubic feet per second is the approximate maximum discharge of 1890 at Fulton. In 1880 a complete series of observations at this place gave a discharge curve extending from low water to within 2 feet of extreme high water, and from this curve the probable maximum discharge of 1882, at a stage of 36.69 feet as published in the report of the Commission for 1883, was 1,288,000 cubic feet per second, or 88,000 cubic feet per second more than in 1890, giving a trifle less than 6 per cent. as the excess of the flood of 1882 over that of 1890 at this point.

At Memphis the discharge at maximum stage was measured at 1,335,000 cubic feet per second. A discharge curve for this place has also been determined from an extended series of observations at Hampton, a few miles below, and from it the maximum discharge of 1882 at 35.2 on the Memphis gauge, as published in the report of 1883, was 1,188,000 cubic feet per second. By this showing the flood of 1890 had a maxi-

mum discharge in the channel exceeding that of 1882 by 147,000 cubic feet per second, or about 12½ per cent.

The aggregate discharge across the parallel of Memphis is obtained by adding to the channel discharge the volume of the swamp wave. The former is 1,335,000 and the latter 500,000, giving a total of 1,835,000 cubic feet per second as the maximum discharge in 1890 over an east and west line through Memphis. A corresponding quantity for 1882, though far less exact, will afford an interesting comparison. In that year the escape into the St. Francis Basin was measured but at stages somewhat below the maximum. An attempt was made to estimate for the maximum stage, and it is believed to have been fairly successful, though several arbitrary assumptions had to be made The result obtained was a probable maximum escape of 611,000 cubic feet per second above Memphis. Adding to this the estimated channel discharge of 1882 at Memphis, as given above, there results 1,799,000 cubic feet per second as the greatest discharge across the parallel of Memphis in 1882, being less by 36,000 cubic feet than the corresponding quantity in 1890. This, though a far from reliable determination, will be allowed to offset in part the deduction for the comparison of channel discharges and the conclusion, if reached, that the floods of 1882 and 1890 at Memphis were practically identical in maximum volume. Both determinations include the discharge of the St. Francis River, supposed to be equal in the two years.

At Helena we have the first direct comparison of actually observed channel discharges in the two floods under consideration. The observed maxima were, in 1882 1,558,000 cubic feet per second, gauge 47.10 feet, and in 1890 1,570,000 cubic feet per second, gauge 47.42 feet, the volume in 1890 exceeding that in 1882 by 12,000 cubic feet per second. The channel discharge at Helena plus the discharge of Austin Crevasse, and that over the bank on the discharge section, gives a total of 1,617,000 as the maximum discharge past Helena, supposing the entire flood to have been concentrated at that point. This, in other words, is the maximum discharge of the flood of 1890 in complete restraint. In 1882 the escape into the Yazoo Basin, between Memphis and Helena, was measured at 290,000 cubic feet per second. This, added to the observed discharge of that year, gives 1,848,000 cubic feet per second as the maximum discharge of that year across the parallel of Helena, a result closely in accord with that obtained at Memphis.

To more clearly show the significance of the foregoing figures, they are grouped in the following table:

Maximum discharge in cubic feet per second.

Locality.	Distance from Cairo.	Flood of 1882.			Flood of 1890.			Differences.*
		In the channel.	Out of the channel.	Total.	In the channel.	Out of the channel.	Total.	
	Miles.							
New Madrid	75	1,603,000	.....	1,603,000	1,412,500	.....	1,412,500	+190,500
Fulton	175	1,288,000	(†)	.....	1,200,000	(†)	.....	+ 88,000
Memphis	232	1,188,000	611,000	1,799,000	1,335,000	500,000	1,835,000	— 36,000
Helena	307	1,558,000	290,000	1,848,000	1,570,000	47,000	1,617,000	+231,000

* +82 greater than 90; —90 greater than 82. † Not determined.

The above table completely analyzes and compares the floods of 1882 and 1890 along the St. Francis front, the only part of the river where such a comparison can be made, because the only part where the conditions were essentially the same in the two years. It shows that the latter flood entered the upper end of the main trunk of the river with a maximum volume 190,500 cubic feet per second less than the former; that at Fulton (assuming that the discharges outside the channel were the same in the two years) this difference was reduced to 88,000 cubic feet; that at Memphis the total maximum discharge per second in 1890 exceeded by 36,000 cubic feet that in 1882, and that on the parallel of Helena the maximum discharge of 1882 was again in excess by the very large amount of 231,000 cubic feet per second. The two floods are also seen to have been very similar in all the features of the distribution of flow as between the channel and the swamp, and also in the different parts of the channel. The conclusion can not be resisted that the flood of 1890 was on the parallel of Memphis, the complete counterpart of the flood of 1882.

Between Memphis and Helena, on the other hand, the table shows that a remarkable change took place in the particular factor of flood regimen which is under consideration, the maximum discharge amounting to a relative difference in the two years of 267,000 cubic feet per second. In 1882, an unrestrained flood, having, on the

parallel of Memphis, a maximum discharge of 1,799,000 cubic feet per second, gave, on the parallel of Helena, 70 miles below, where it was also unrestrained, a maximum discharge in channel and swamp at 1,848,000 cubic feet per second. In 1890 a flood identical in all its features with that of 1882 on the parallel of Memphis, but gradually confined to the channel between there and Helena, passed the latter point entirely in the channel with a maximum discharge less by 231,000 cubic feet per second than that of 1882.

It has been the usual if not universal practice for engineers investigating the subject, to assume that floods of equal magnitude must have the same maximum discharge whether restrained or not. In considering the question of height of embankments to restrain a flood of known magnitude the aggregate maximum discharge in channel and swamp has been assumed as the maximum to be passed between the levees. From a known relation of gauge and discharge for an unrestrained flood, the surface height necessary to pass this assumed maximum has been deduced, and the enormous resulting elevations have been the perpetual nightmare of levee enterprise. If the experience of this year at Memphis and Helena means anything, it is that that method of deduction and the results obtained by it are radically wrong. The relative magnitudes of floods can not be gauged by the maximum discharges at a given point, unless the conditions of restraint are essentially the same. A flood confined to the channel will have a less maximum discharge than the same flood without restraint, and so far as this single determination may be relied upon quantitively, the maximum discharge of a flood confined to the channel will be but little greater than the maximum discharge in the channel of the same or an equivalent flood unrestrained.

The question of restraint of a great stream like the Mississippi River usually presents itself to the mind with most vividness at the time when its need is most apparent, or when an instant flood is in its full career of devastation. Though illogical, it is perhaps natural that the problem should take a form like this. What would be the effect of suddenly squeezing this vast expanse of water up between two parallel walls 5,000 or 6,000 feet apart? The answer is at hand without argument or question. It would be to raise the surface to a height so great that is is useless to speculate upon its exact measurement.

The circumstances under which restraint should be viewed theoretically are those under which it is an engineering possibility. The barriers can only be erected when the water is absent, and the rising river, as its surface attains the level of the natural banks, will find the wall in place and the low country behind it dry. The river will then be under the new conditions from this moment until the rise has culminated, and these new conditions, antecedent to the maximum at the flood, must enter largely in determining the amount of that maximum. How largely and in what direction, it is believed the above data constitute a demonstration.

Onto a flood past Helena fully equal to that of 1882 was discharged a very large volume of water from White and Arkansas rivers. White River especially contributed very much more water than it has ever been known to do, so far as may be judged by the number of flood waves and their heights in the valley proper of that stream. The levee at Laconia Circle, near the confluence of the Mississippi and White, was first broken by the wave wash of a series of wind-storms, and finally overwhelmed by a flood which rose 2 feet higher than any previous record. Aside from this, the only break in the first and second districts was a small one in the Upper Mississippi district at Austin, 288 miles below Cairo, which broke April 3. It did not enlarge after first observed, and its discharge was measured at 37,370 cubic feet per second the day after it broke. The cause of the break was a seep hole in the ground under the levee, which suddenly broke out while operations were in progress to stop it.

The levees on Plum Point Reach and on the White River Front near Helena were patrolled and guarded by United States employés during the entire flood period. Prompt measures were taken to protect places injured or likely to be so. All damage resulted from wave wash on the front slope, and was met by revetments of sacks filled with earth and bagging, held in place by stakes or sacks. At Helena the brunt of the fight was made by the local levee board. An assistant engineer was constantly on the ground, but they left him very little to do. No attention was paid in these districts to the Mississippi levees, which were attended to exclusively by the State authorities.

A comparison of the grade of the Mississippi levees above White River shows that in the decade 1880–1890 they have been raised as follows: At the upper end of the line at Horn Lake, 2 feet, increasing gradually to 3½ feet opposite the St. Francis River, decreasing to 2½ feet near Friar's Point, and again increasing to 3 feet at the lower end of the outside line opposite Island 66. From above Hushpuckena to the Coahoma-Bolivar line the increase has averaged 2¼ feet.

The back line has been extended northward in the same period a distance of 9 miles, with a grade of 1½ feet above high water of 1882 at Hushpuckana. Continuous escape of water between the two lines through Lewis swamp is absolutely prevented.

From 2 feet near the Coahoma-Bolivar line the raise of grade has gradually increased to 3½ feet opposite the mouth of White River.

As in the case of the first district, for the same reason and from the same data, an estimate of 3,500,000 tons per annum is made as the total volume of traffic through the whole or parts of the second district. A statement of the tonnage of the port of Memphis from official sources is appended.

EXHIBITS.

There are submitted with this report a map of Helena Harbor, showing amount and location of work done and to be done; a financial statement and general balance sheet for all allotments to the second district; a statement of disbursements from these allotments classified as to the manner of making them, as required by law; abstracts of proposals in cases of expenditures by formal contract; itemized statements of expenditures on various works; a table of value of plant second district, and a list of civilian engineers employed during the year in the first and second districts.

Very respectfully, your obedient servant,

SMITH S. LEACH,
Captain of Engineers.

Gen. C. B. COMSTOCK,
President Mississippi River Commission.

APPROPRIATION FOR IMPROVING MISSISSIPPI RIVER, SECOND DISTRICT.

Money statement.

June 1, 1889, balance available		$97,576.23
October 12, 1888, amount allotted by Board of District officers for protection of levees, second district	$5,000.00	
June 5, 1889, amount allotted by Mississippi River Commission for Memphis Reach	20,000.00	
March 22, 1890, amount transferred from allotment for Plum Point Reach to protection of levees, second district	2,500.00	
		27,500.00
Total		125,076.23
November 11, 1889, amount expended by general service on account Helena, Ark	10,393.17	
March 18, 1890, amount transferred from allotment for Memphis Reach to protection of levees, fourth district	20,000.00	
June 30, 1890, amount expended from June 1, 1889, to date, exclusive of liabilities outstanding June 1, 1889	65,831.18	
June 30, 1890, outstanding liabilities	208.10	
		96,432.45
June 30, 1890, balance available		28,643.78
Amount that can be profitably expended in fiscal year ending June 30, 1892		750,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

General balance sheet.

MEMPHIS REACH.

1889.			1890.		
June 1	To balance, including estimated liabilities	$22,866.24	Mar. 18	By amount transferred to protection of levees, fourth district	$20,000.00
June 5	To amount allotted by Mississippi River Commission	20,000.00	June 30	By amount expended to date	6,687.57
				By liabilities	2.00
				By balance	16,176.67
		42,866.24			42,866.24

General balance sheet—Continued.

MEMPHIS HARBOR.

1889. June 1	To balance	$14,833.75	1890. June 30	By amount expended to date	$9,214.01
				By liabilities	71.10
				By balance	5,548.64
		14,833.75			14,833.75

LEVEES, WHITE RIVER FRONT.

1889. June 1	To balance	$3,954.35	1890. June 30	By balance	$3,954.35

FIRST LEVEE DISTRICT, MISSISSIPPI.

1889. June 1	To balance	$7,677.84	1890. June 30	By amount expended to date	$7,167.76
				By balance	510.08
		7,677.84			7,677.84

OBSERVATIONS AND DISCHARGES, SECOND DISTRICT.

1889. June 1	To balance, including estimated liabilities	$783.32	1890. June 30	By amount expended to date	$781.25
				By balance	2.07
		783.32			783.32

GAUGES, SECOND DISTRICT.

1889. June 1	To balance, including estimated liabilities	$822.50	1890. June 30	By amount expended to date	$540.00
				By liabilities	135.00
				To balance	147.50
		822.50			822.50

SURVEY AND EXAMINATIONS, SECOND DISTRICT.

1889. June 1	To balance	$2,913.96	1890. June 30	By amount expended to date	$1,338.90
				By balance	1,575.06
		2,913.96			2,913.96

HELENA, ARKANSAS.

1889. June 1	To balance, including estimated liabilities	$72,251.11	1890. June 30	By amount expended to date	$61,855.14
				By amount expended by general service to date	10,393.17
				By balance	2.80
		72,251.11			72,251.11

General balance sheet—Continued.

PROTECTION OF LEVEES, SECOND DISTRICT.

1888. Oct. 12	To amount allotted by Board of District Officers.	$5,000.00	1890. June 30	By amount expended to date	$1,595.55
1890. Mar. 22	To amount transferred from allotment for Plum Point Reach	$2,500.00		To balance	5,904.45
		7,500.00			7,500.00

APPROPRIATION FOR IMPROVING MISSISSIPPI RIVER, FIRST AND SECOND DISTRICTS.

Money statement.

June 1, 1889, balance available		$1,779.80
June 5, 1889, amount alloted by Mississippi River Commission for care of plant, first and second districts		60,000.00
Total		61,779.80
June 30, 1889, amount expended from June 1, 1889, to date, exclusive of liabilities outstanding June 1, 1889	$40,072.35	
June 30, 1889, outstanding liabilities	2,705.08	
		42,771.43
June 30, 1890, balance available		19,002.37
Amount that can be profitably expended in fiscal year ending June 30, 1892		70,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

General balance sheet.

CARE OF PLANT, FIRST AND SECOND DISTRICTS.

1889. June 5	To amount allotted by Mississippi River Commission	$60,000.00	1890. June 30	By amount expended to date	$39,547.85
				By liabilities	2,705.08
				By balance	17,747.07
		60,000.00			60,000.00

SURVEYS, FIRST AND SECOND DISTRICTS.

1889. June 1	To balance, including estimated liabilities	$2,029.80	1890. June 30	By amount expended to date	$774.50
				By balance	1,255.30
		2,029.80			2,029.80

SECOND DISTRICT.

Disbursements made under appropriations for improving Mississippi River; acts of August 5, 1886, *and August* 11, 1888.

[June 1, 1889, to June 1, 1890.]

Contracts made with—	For what made—	Disbursements under contract.	Liabilities under contract.	Total.
Hunter & Frey	Willow brush and poles	$7,825.59		$7,825.59
Fudge & Kearns (balance)*	Levee work	6,774.93		6,774.93
		14,600.52		14,600.52

*Part payment reported in 1889.

Disbursements made otherwise than under contract.

For what expended.	By public notice and sealed proposals.	In open market.	Liabilities.	Total.
Material and supplies	$14,342.06	$6,652.05	.....	$20,994.11
Subsistence	3,815.87	2,510.35	.....	6,326.22
Services	.....	41,270.74	$90.00	41,360.74
Tools and appliances	434.73	4,644.81	.....	5,079.54
Miscellaneous	.....	595.94	.....	595.94
	18,592.66	55,673.89	90.00	74,356.55

FIRST AND SECOND DISTRICTS.

[June 1, 1889, to June 1, 1890.]

Disbursements made otherwise than under contract.

For what expended.	By public notice and sealed proposals.	In open market.	Liabilities.	Total.
Material and supplies	.....	$233.12	.....	$233.12
Subsistence	.....	86.50	.....	86.50
Services	.....	35,306.24	$3,500.00	38,806.24
Tools and appliances	.....	27.50	.....	27.50
Miscellaneous	.....	364.66	.....	364.66
	.....	36,018.02	3,500.00	39,518.02

Abstract of proposals for furnishing willow brush, and poles at Helena, Arkansas, received in response to advertisement dated June 20, 1889, by Captain Smith S. Leach, Corps of Engineers.

No.	Name and address of bidder.	10,000 cords of willow brush.	2,000 cords of willow poles.	Total.
		Per cord.	*Per cord.*	
1	A. C. Terrell, Memphis, Tenn	$1.20	$1.62½	$15,250.00
2	Joseph Evins, Dardanalle, Ark	1.19	1.50	14,900.00
3	Elisha Evans, Memphis, Tenn	1.04	1.65	13,700.00
4	L. A. Fitzpatrick, Helena, Ark	1.20	1.75	15,500.00
5	Hunter & Frey, Memphis, Tenn	*.90	*1.47	*11,940.00
6	Nathan W. Tucker, St. Louis, Mo	(†)	(†)	(†)

* Accepted. † No prices stated in proposals.

Statement of expenses for work done at Helena, Arkansas, from August 21, 1889, to February 1, 1890.

Items.	Administration.	Care of plant.		General repairs.		Steamers.		River mattress.		Crib-dikes.		Embankment.		Unloading stone.	Total.		Percentage.
	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.	Cost.	Amt.	Cost.	
Labor	$2,448.25	.....	$2 033.58	.....	$1,201.48	.....	$1,791.50	.....	$8,734.09	.....	$5,722.42	.....	$1,135.41	$182.40	.....	$23,249.13	41.57
Subsistence services	72.35	.....	239.36	.....	75.79	.....	206.33	.....	579.59	.....	390.36	.....	54.41	.....	.....	1,618.19	2.89
Subsistence stores	219.72	.....	780.93	.....	265.12	.....	354.10	.....	2,354.02	.....	1,530.93	.....	247.94	.....	.....	5,752.76	10.29
Brush.....cords..	.....	.....	.....	.....	.....	.....	.....	4,201	3,780.90	1,822	1,639.80	.....	.....	.....	6,023	5,420.70	9.69
Poles.....do....	.....	.....	.....	.....	.....	.....	.....	631	933.88	482	718.36	.....	.....	.....	1,113	1,652.24	2.96
Piles.....feet..	.....	.....	.....	.....	.....	.....	.....	2,080	135.50	1,040	104.00	.....	.....	.....	3,120	239.50	0.43
Stone.....cubic yards..	.....	.....	.....	.....	.....	.....	.....	3,400	6,600.26	1,818	3,529.19	726	1,409.34	.....	5,944	11,538.79	20.63
Wire.....pounds..	.....	.....	.....	.....	.....	.....	.....	45,301	1,232.63	28,320	787.32	.....	.....	.....	73,621	2,019.95	3.62
Wire strands.....do....	.....	.....	.....	.....	.....	.....	.....	6,780	258.70	3,146	138.51	.....	.....	.....	9,926	397.21	0.71
Iron.....do....	.....	.....	.....	1,867	48.71	16	40	2,353	59.31	3,221	77.53	.....	.....	.....	7,457	185.95	0.33
Spikes.....do...	.....	.....	.....	.....	.....	.....	.....	4,230	105.85	4,084	102.70	.....	.....	.....	8,314	208.55	0.37
Nails.....do....	.....	.....	.....	600	15.00	.....	.....	.....	.....	400	10.00	100	2.50	.....	1,100	27.50	0.05
Coal.....boxes..	.....	485	165.12	430	147.75	3,179	1,080.13	195	62.88	70	23.75	.....	.....	.....	4,959	1,479.63	2.65
Lumber.....feet..	.....	.....	.....	14,159	212.34	299	5.23	3,222	46.71	56,678	555.66	7,400	51.80	.....	81,758	871.74	1.56
Manilla rope.....pounds..	.....	.....	.....	.....	.....	.....	.....	2,950	390.90	2,190	284.70	.....	.....	.....	5,140	675.66	1.21
Gravel.....cubic yards..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	79	23.70	.....	79	23.70	0.04
Oakum.....pounds..	.....	.....	.....	75	6.08	.....	.....	.....	.....	.....	.....	.....	.....	.....	75	6.08	0.01
Paints	.....	.....	.....	.....	10.56	.....	8.82	.....	.62	.....	1.72	.....	.....	.....	.....	19.38	0.03
Oils and engineers' supplies	.....	.....	70.12	.....	15.42	.....	61.96	.....	.....	.....	.....	.....	.....	.....	.....	149.84	0.27
Miscellaneous	116.44	.....	95.60	.....	24.23	.....	55.20	.....	48.72	.....	40.25	.....	7.12	.....	.....	387.56	0.69
Total	2,856.76	.....	3,384.71	.....	2,022.48	.....	3,563.67	.....	25,324.62	.....	15,657.20	.....	2,932.22	182.40	.....	55,924.06	.....
Percentage	5.11	.....	6.05	.....	3.62	.....	6.37	.....	45.28	.....	28.00	.....	5.25	0.32	.....	.....	100.00
Work done	.....	.....	.....	.....	.....	9 mats = 6,493 squares made .... 7 mats = 5,180 squares covered.. 2 mats = 1,313 squares lost		.....		7 cribs = 355,672 cubic feet.		51,868 cubic feet and 1,495 square yards of paving.		2,125 cubic yards.			
Cost per unit	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

Cost per unit: $3.90 per square made. $4.89 per square covered. — $0.044 per cubic foot. — $0.0565 per cubic foot. — $0.086 per cubic yard.

SECOND DISTRICT, IMPROVING MISSISSIPPI RIVER, MEMPHIS HARBOR.

Itemized statement of expenditures for repairs of dikes.

Items.	Office and general administration.	Dikes.			Total.
		Gravel and stone.		Earthwork.	
		Quantity.	*Price.*		
Labor	$450.00	.....	$992.95	.....	$1,442.95
Stone	.....	3,582 yds	6,553.70	.....	6,553.70
Gravel	.....	983⅓ yds	295.00	.....	295.00
Earthwork	.....	9,123 yds	.....	$3,002.43	3,002.43
Lumber	.....	.....	20.10	.....	20.10
Rope	.....	387 lbs	52.25	.....	52.25
Tools and appliances	.....	.....	34.00	.....	34.00
Towing	.....	.....	31.00	.....	31.00
Miscellaneous	72.00	.....	4.45	.....	76.45
Total	522.00	.....	7,983.45	3,002.43	11,507.88

Approximate value of plant belonging to the United States and used upon the improvement of the Mississippi River, second district.

Class of property.	No.	Approximate value May 31, 1890.	Class of property.	No.	Approximate value May 31, 1890.
Steamer *H. M. Graham*	1	$2,671	Barges	23	$10,675
Launch *Dauphin*	1	560	Skiffs	26	200
Flat-boats	2	326	Tools and appliances	....	1,882
Mattress boats	2	4,192	Office furniture	....	180
Machine boat	1	2,569	Surveying instruments	....	105
Mooring barges	4	1,918			
Quarter-boats	5	2,903	Total	....	38,090
Pile-drivers	9	9,909			

List of civilian engineers employed on work of improving Mississippi River, first and second districts, in charge of Capt. Smith S. Leach, Corps of Engineers, from June 1, 1889, to May 31, 1890, under river and harbor appropriation acts, approved August 5, 1886, and August 11, 1888.

Name and place of residence.	Time employed.	Compensation per month.	Where employed.	Work on which employed.
	M. D.			
Aug. J. Nolty, Chattanooga, Tenn.	12	$150	Plum Point Reach ...	Improving Mississippi River, Plum Point Reach.
W. M. Rees, Memphis, Tenn.	2	175	Memphis, Tenn	Improving Mississippi River, Memphis Reach.
	9	200	Memphis and Helena.	Improving Mississippi River, Memphis Reach and Helena, Ark.
Chas. W. Stewart, Champaign, Ill.	2	120	Plum Point Reach	Surveys.
	4	140	Hickman, Ky	Improving Mississippi River, Hickman, Ky.
	4	140	Columbus, Ky	Improving Mississippi River, Columbus, Ky.
	2	140	Helena, Ark	Protection of levees, second district.
Wm. Gerig, Columbia, Mo	3 24	130	New Madrid, Mo	Observations and discharges, first district.
	4	130	Memphis, Tenn	Improving Mississippi River, Memphis Harbor.
	3	130	....do	Observations and discharges, second district.
	1 6	130	....do	Surveys and examinations, second district.

List of civilian engineers employed on work of improving Mississippi River, etc.—Continued.

Name and place of residence.	Time employed.	Compensation per month.	Where employed.	Work on which employed.
	M. D.			
C. W. Sturtevant, Appleton City, Mo.	7	$120	Plum Point Reach....	Surveys.
	3	120	Memphis, Tenn.....	Do.
	2	130	Helena, Ark	Observations and discharges, second district.
S. Elliott Moore, Memphis, Tenn.	3 26	150	Memphis, Tenn	Survey of St. Francis Front.
	1 11	140	Buke's Landing, Miss..	Levee inspector.
T. G. Dabney, Clarksdale, Miss.	3¾	120	...do	Do.
Eugene L. Harman, St. Louis, Mo.	25	130	New Madrid, Mo.....	Surveys and examinations, first district.

Commerce, by river, of the city of Memphis, Tennessee, during the year ending December 31, 1889, *as reported by the Merchants' and Cotton Exchanges.*

Articles.	Imports.	Exports.	Articles.	Imports.	Exports.
	Tons.	*Tons.*		*Tons.*	*Tons.*
Apples	490	636	Hay	425	11,317
Bran	593	1,265	Hats and caps	3	56
Beans and peas	66	369	Live stock	581	4,612
Butter	20	18	Lard	151	304
Bagging	3,668	1,091	Lumber	370	1,550
Bacon	987	1,255	Liquors	93	252
Boots and shoes	53	552	Lime	30	464
Coal*	125,000	.....	Meal	1,552	1,849
Corn	598	5,409	Molasses	1,919	2,004
Cotton†	31,110	9,322	Nails	2,368	1,030
Cotton-seed	46,852	.....	Oats	107	4,388
Cotton-seed meal	105	.....	Onions	280	163
Cotton-seed oil	11,056	5,951	Potatoes	1,214	1,219
Cotton-seed oil cake	.....	23,869	Pork	90	3,841
Cotton-ties	75	626	Rice	15	237
Cheese	6	136	Sugar	3,714	1,413
Coffee	163	509	Tobacco	38	249
Cement	1,079	392	Wheat	30	38
Dry goods	1,003	1,325			
Eggs	16	17	Total	275,778	93,898
Flour	9,858	6,208			

* For two months ending May 31, 1890.

† For twelve months ending May 29, 1890.

APPENDIX H.

REPORT OF CAPTAIN WILLARD YOUNG, CORPS OF ENGINEERS, UPON OPERATIONS IN THE THIRD DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 2, 1890.

GENERAL: I have the honor to submit the following report of operations in the third district, improving Mississippi River, for the year ending May 31, 1890:

The district was in charge of Capt. William T. Rossell, Corps of Engineers, from June 1, 1889, to November 2, 1889; Capt. Smith S. Leach, Corps of Engineers, from November 2, 1889, to December 21, 1889; Capt. Willard Young, Corps of Engineers, from December 21, 1889, to May 31, 1890.

The third district extends from the mouth of White River, Arkansas, to Warrenton, Miss., a distance of 220 miles. The improvements within the district consist of those works undertaken for the general improvement of the channel, and, besides, those of a local character intended for a special purpose.

The improvements at Lake Bolivar and at Greenville and Vicksburg harbors are of

the latter class. The former class comprises the works of surveys, examinations, observations, etc., intended for the collecting of general data; of levee building, repair, and protection; and more especially of bank protection and channel contraction works.

The operations for the year, in carrying on the various works, will be noted in order.

LAKE PROVIDENCE REACH.

The works of bank protection and channel contraction already begun in the third district for general channel improvement are all comprised within the Lake Providence Reach, which extends from Carolina Landing, Miss., to the foot of Island No. 95, a distance of 35 miles.

The physical characteristics of this portion of the river prior to improvement, the methods employed and the work done in improving the channel up to the year 1889, and the then condition of the river and of the several works of improvement, are described in the reports of the Commission for previous years.

The operations for the year ending May 31, 1890, were confined to bank-protection work at Louisiana Bend.

Preliminary work was commenced June 1 under the direction of Mr. E. C. Tollinger, assistant engineer; on June 19 the charge of the work was given to Mr. H. St. L. Coppee, assistant engineer.

He was relieved by Mr. Arthur Hider, assistant engineer, on August 20, who remained in charge till the close of operations December 31.

The details of the whole season's operations are given in the following report of Assistant Engineer Hider.

The revetting of the bank actually above water consisted of a continuous pavement of stone, laid by hand, and about 10 inches thick.

The revetments above water heretofore constructed at this and other points on the river have consisted of willow mattresses, over which stone has been scattered more or less thickly by hand. The new continuous stone pavement costs from two to four times as much as the old style willow and stone revetment, depending upon the amount of stone used in the latter.

The pavement above water is, however, but a small part of whole revetment, and the extra cost of the continuous stone-work is thought to be more than justified on account of its greater permanency and stability.

Bank protection is the foundation, and, I might say, almost the whole structure, upon which the success of channel improvement work depends. Without it no adequate results can possibly be obtained. With banks properly and permanently protected it will be possible to secure and forever maintain in this reach, and throughout the third district, a channel of ample depth for all the needs of commerce.

REPORT OF MR. ARTHUR HIDER, ASSISTANT ENGINEER, ON OPERATIONS IN LAKE PROVIDENCE REACH FOR THE YEAR ENDING MAY 31, 1890.

Work was begun in June revetting this bend, in accordance with the plans adopted by the Commission, which consisted in the construction of a wide mattress extending out from the low-water line, grading the upper bank to a regular slope, and revetting it from the zero line to the top with riprap.

During June little progress was made in mat-building; 25 feet of mat No. 1, which was 260 feet wide, had been built at the end of the month. In July, 1,027 linear feet of mat was constructed, the lower 727 feet being increased to 300 feet in width on account of the deep water.

In the beginning of August mat No. 1 was completed and the upper 900 feet sunk in place; the building was continued, the lower end still floating on the surface, until a length of 1,315 feet had been reached, when this part was sunk.

In sinking this lower end, the mat broke nearly across the entire width, about 800 feet below the head, and the outer edge buckled, lapping over towards the middle; the water was here about 70 feet deep.

The mat not being well secured to the shore, floated out from the bank; with the aid of a steam-boat it was sunk to the bottom after a good deal of trouble, and in a very unsatisfactory shape.

Mat No. 2, 1,000 by 342 feet, was built and sunk on August 23. On August 24 I as-

sumed charge of the work, relieving Assistant Engineer Coppée, under whose direction the work had been organized and carried on.

Work was at once begun in the construction of mat No. 3. At the end of August there had been built of—

	Feet.
Main mat	565 by 342
Shore mat No. 1	180 by 50
Shore mat No. 2	180 by 75
Shore mat No. 3	104 by 75

These were built to cover the space between mat No. 1 and the shore. In September the mats built were:

	Feet.
Main mat	1,145 by 342
Shore mat No. 4	619 by 171
Shore mat No. 5	380 by 145

The shore mats were to cover the bottom between the edge of main mat No. 1, which slipped out as the bank was being graded, and the shore.

There was constructed—

	Feet.
In October:	
Main mat	1,450 by 342
Pocket mat (6)	300 by 145
In November:	
Main mat	340 by 345
Shore mat No. 7	381 by 150
Shore mat No. 8	310 by 345
Shore mat No. 9	1,047 by 111

The shore mats Nos. 7 and 9 were built so as to overlap the main mattress, which thus made the revetment continuous above the water, as the river was rising rapidly.

Shore mat No. 8 was constructed to protect the foot of the slope, which had cracked and slipped down, due to the fault in sinking mat No. 1. During December shore mat (10), 1,067 by 128 feet, was constructed overlapping the main mat, and continues up the slope, which had only been partially graded; on account of the river rising so rapidly after the completion of the main mattress, there was insufficient time to do this grading.

The total length of bank covered was 6,024 linear feet, the overlapping of the mattress, one on the other, not being included.

The usual method of mattress construction was followed in building these large mats, which are perhaps the widest yet attempted on the river for revetment purposes; the only change was in giving additional strength by weaving in seven-eighths inch wire cables longitudinally through the mat, spaced every 16 feet, and placing holding in cables, extending entirely across the mat at the same distance apart.

These were pulled taut with a pair of tackle-blocks, after the upper slope had been graded, and securely fastened to dead men or trees on the top of the bank to prevent slipping out of the main mattress should a cave take place.

As instructed, the grading of the upper bank was done after the mattress had been sunk in place to a slope carrying from 1 on 3 to 1 on 5, depending on the inequalities of the shore-line, which at many points was indented by large pockets, due to caving.

This slope was afterwards covered with stone, laid by hand, of an average depth of about 10 inches, extending from the low-water line up to the top of the bank.

In this connection it may be interesting to note some of the difficulties encountered in executing the work.

As to mat sinking.—In sinking the first mat, which was done before I took charge, a great deal of difficulty was experienced.

The mat was constructed with its inner edge held out to the zero line by a row of piles driven along the shore; the upper 900 feet was sunk first, and while this part was in place on the bottom the building was continued by adding on to the lower end.

In sinking this, the excessive strain brought on the part reaching from the bottom to the surface of the water while the mat was being lengthened, and the unequal strain due to the rock thrown from barges on this part of the mat, added to the pressure of the current against the long slope, which it would necessarily assume in 70 feet of water, broke the mat, and the fact of but few holding-in cables being used, the mat floated out from the shore before it could be sunk to the bottom, the outer edge rising and buckling; the twisting of the mat causing the rock on the lower end to slide toward the middle.

The method of continuous building and sinking mats of these dimensions can not be recommended.

For mats of much smaller width, from experience gained several years ago, this plan was abandoned, as attended with a great risk of injury and danger of loss.

The plan heretofore followed is to ballast the entire surface of the mat evenly, so as to nearly destroy the flotation, and then complete the loading from barges, beginning at the head and sinking the entire mat at once.

The breaking up of this mat was undoubtedly due to the method adopting of sinking, as no difficulty was experienced with any of the others; under ordinary circumstances, and where proper precautions are taken, no trouble in sinking these large mats need be anticipated, as instanced by work of this class previously done at Greenville, Bolivar, and the other large mats afterwards constructed here.

On September 10, a month after mat No. 1 had been sunk, while the upper slope was being graded, the bank began slipping out, parting the few holding-in cables and pushing out the mat itself, as shown by willows forced up to the surface by the movement of the mat below.

This sliding of the upper bank continued at intervals, as the grading proceeded, as far down as station 17, necessitating the building of a number of large and expensive mats afterwards to connect the main mat with the shore.

The trouble, it is thought, was caused by the great quantity of water pouring down the slope, thoroughly saturating the lower part, until the material became in a semi-fluid condition, which, being forced against and under the mat, moved it bodily out into the river, as at this particular locality the bottom was soft, formed by a deposit of silt, which when once put in motion carried with it the mat.

In all the other mats the full number of shore cables were put in (every 16 feet) and the precaution taken to pull them up taut with a pair of small blocks, following up close behind the grading.

No more slipping took place.

Grading the slope.—Much more could have been accomplished, and a great deal of expense saved, in the execution of the work, had the grading preceded instead of followed the mat construction.

Among the practical difficulties arising from grading the high banks after the mattresses are in place, may be enumerated the fact that the saturation of the slope by the stream of water running over it, where the material is sand or silt, causes holes and caving and breaking down of the edge near the water-surface.

It is necessary, in order to keep up with the mat-building, to fill these holes with earth and lay the stone on without sufficient time for settlement, whereas, had the grading been done first, the grade would be in much better condition to receive the stone covering, having had more time to settle.

The cables which hold the mat into the shore are led over the top of a nearly vertical bank and fastened before the mat is sunk. In bringing the upper bank to the proper slope the scare loosened, and give no assistance to prevent the sliding out of the mat at a time when it is subjected to an enormous strain from the slipping down against its edge of the material washed from the bank in a semi-fluid condition.

Inasmuch as the low-water season is of short duration, and it is only at the lowest stages that the upper bank grading can be carried on, the amount of revetment work that can be finished in any one season depends upon the length of bank that can be graded before the river rises.

And as the grading is necessarily the length of one mat from 800 to 1,000 feet behind (by reason of the space occupied by the head and mooring lines to the lower mat under construction), it is compulsory to stop mat-building before the river rises to any extent, in order to have sufficient time to grade and revet the slope in front of the mat, or else leave this work in an unfinished condition with the lower part of the slope ungraded.

Among the advantages of grading ahead of the mat construction are—

First. The graded bank allows the holding-in cables to be permanently fastened before the mat is sunk in place, thus preventing any slipping or sliding out of the mat from the shore.

Second. The whole of the low-water season can be utilized for work in mat-building; the mat construction can be carried up the graded slope as the river rises, thus allowing more work to be accomplished.

Third. It is a great saving of expense, as the graded slope affords ample space to unload rock from barges at the place it is to be afterwards used, and thus saves the expense of rehandling.

The revetment work was finished on December 31, and from the last examination made before the rise in the river covered it with water, was in good condition, except a small part of the extreme lower end of the upper bank, which had slid in, due to caving below the end of the work. Plate 1 shows location of mats as constructed.

The following amount of work was done:

Mattress	squares..	21,694.7
Slope paving	do....	5,671.8
Grading	linear feet..	5,877.0
Material used:		
Stone	cubic yards..	48,160.82
Brush	cords..	18,813.30
Poles	do....	3,362.15
Wire	pounds..	167,440.00
Wire cables	do....	329,560.00
Spikes	do....	36,961.06

The fleet was towed from Wilson's Point, La., to Ashton, La., during June, and on the completion of the Louisiana Bend improvement, December 31, was moved to Greenville.

All the plant, including the old drydock, was brought up without accident. The last tow arrived January 23, 1890.

REPAIRS.

A force of mechanics has been employed in making repairs to the plant. The most important done was remodeling the pits of the two dump-scows built for use in Vicksburg Harbor.

The repairs to the steamer *Meter*, which consisted of new cylinder timbers, new guards and outriggers, a square head put on to adapt her better for towing purposes, new rudders, and extensive repairs to her hull.

The docking and repairs to hull of the headquarters boat, and the rebuilding of two small barges, besides new decks and deck frames put in three of the rock-barges.

Material expended, June 1 to April 30, inclusive.

Stone	cubic yards..	48,160.82	Gas-pipe	feet..	100
Brush	cords..	18,813.30	Limestone	barrels..	15
Poles	do....	3,362.15	Lime	do....	3
Lumber	B. M..	179,994	Asphaltum	do....	6
Coal	bushels..	92,407	Salt	do....	5
Wire cable	pounds..	329,560	Charcoal	do....	5
Wire	do....	167,440	Oil (head-light)	gallons..	1,945
Spikes	do....	36,961	Linseed oil	do....	855
Iron	do....	36,185	Oil (signal)	do....	815
Lead (white and red)	do....	5,785	Oil (lard)	do....	385
Oakum	do....	6,138	Oil (valvoline)	do....	162
Staples	do....	800	Oil (black)	do....	171
Clevises	do....	300	Turpentine	do....	50
Copper	do....	5	Asphaltum	do....	476
Files	No..	135			

Summary of cost of labor, June 1, 1889, to April 30 1890, inclusive.

Classification.	Pay-roll.	Subsistence.	Total.
Care of fleet	$15,631.93	$2,788.41	$18,420.34
Surveys and examinations	2,408.67	512.92	2,921.59
Surveys Lake Providence Reach	1,220.00	140.73	1,360.73
Observations Wilson's Point	1,992.67	415.31	2,407.98
Observations Arkansas City	786.24	185.00	971.24
Protection of levees	43,118.02	4,003.97	47,121.99
Vicksburg Harbor	3,098.28	550.90	3,649.18
Repairs to plant	16,023.51	2,894.15	18,917.66
Louisiana Bend (construction)	57,899.28	13,779.88	71,679.16
Greenville Harbor	.....	13.86	13.86
	142,178.60	25,285.13	167,463.73

Tri-monthly soundings on Lake Providence Reach.

Date.	Lake Providence gauge.	Crossings.					
		Duncansby.	Wilderness.	Vista.	Stack Island.	Ben Lomond.	Ajax Bar.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
June 7	19.50	35.00	.....	.....	.....	.....	.....
8	20.50	.....	31.0	.....	30	24.0	.....
24	25.50	45.00	31.0	.....	27	29.0	.....
July 10	23.75	43.00	25.0	.....	27	30.0	.....
20	17.75	35.00	21.0	.....	19	19.0	.....
31	18.75	41.00	24.0	.....	24	21.0	.....
Aug. 11	19.00	43.00	19.0	.....	21	19.0	.....
21	14.25	32.00	17.0	.....	22	17.0	.....
31	11.00	12.50	15.0	.....	16	12.0	.....
Sept. 10	7.75	27.00	13.0	.....	13	13.0	.....
20	10.75	28.00	15.0	.....	17	14.0	.....
30	8.5	27.00	14.0	.....	14	12.0	.....
Oct. 11	6.5	23.00	13.0	12.0	12	10.5	.....
21	4.25	18.50	11.0	10.0	12	8.0	.....
31	3.00	17.00	12.0	8.5	11	8.5	.....
Nov 1	2.25	17.00	12.0	8.5	11	8.5	7.0
11	5.90	20.00	17.0	13.0	13	11.5	10.5
20	16.50	29.00	20.0	23.0	20	20.0	21.0
30	23.00	40.00	28.0	35.0	26	25.0	28.0
Dec. 10	24.25	37.00	28.5	33.0	30	26.0	30.0
20	15.75	31.00	21.0	21.0	20	17.0	20.0
30	17.00	35.00	21.0	26.0	24	16.0	22.0
Jan. 11	23.00	41.00	24.0	29.0	33	18.5	24.0
20	30.25	50.00	32.0	39.0	42	26.0	33.0

Soundings were discontinued after January 20 on account of the high stage of the river.

FINANCIAL STATEMENT.

Lake Providence Reach.

Balance May 31, 1889		$467,046.33
Transferred to protection of levee, third district	$55,000.00	
Transferred to protection of levee, fourth district	45,000.00	
Expended to June 30, 1890	360,519.67	
		460,519.67
Balance June 30, 1890 (in hand)		6,526.66
Expenditures apportioned as follows:		
Labor on construction		51,632.62
Material for construction		199,431.48
Subsistence		27,557,46
Cost of plant, repairs, and outfit		40,229.37
Care of public property		19,229.90
Towage and steamer expenses		11,345,29
Administration and office expenses		7,026.94
Surveys		1,941.09
Medicines and medical attendance		1,207.72
Miscellaneous		917.80
		360,519.67
Balance June 30, 1890	6,526,66	
Less liabilities	3,006.56	
Available balance June 30, 1890		3,520.10

There are no existing contracts.

Amount that can be profitably expended in fiscal year ending June 30, 1892 ..... 750,000.00

VICKSBURG HARBOR AND DELTA POINT.

Until the year 1876 the Mississippi River flowed directly in front of the city of Vicksburg. In that year the river made a cut-off across the narrow neck of land forming the opposite bank, thus leaving the city on a lake, and its wharves and business houses distant from the river about 2 miles. The rapid caving of the bank at Delta Point, Louisiana, opposite Vicksburg, after the occurrence of the cut-off threatened to throw the river still farther away from Vicksburg, while the rapid and continuous shoaling of the lake, and especially of the entrances thereto, tended to prevent direct communication with Vicksburg, except during the higher stages of the river. It was thus seen that Delta Point should be held, to prevent further recession of the river from Vicksburg and to maintain the regimen of the river immediately below, and that an improvement of the harbor proper (Centennial Lake, in front of the city) was desirable.

The protection of Delta Point, by revetment, was commenced in 1878, and was carried on in succeeding years until 1884, since which date only repair work has been done. Altogether 10,700 linear feet of bank was revetted. The work has proved entirely successful. It will need repairing, however, from time to time to insure its permanency, and may have to be extended up-stream, should rapid caving there continue. No repairs were made during the past year.

Several plans for the improvement of Vicksburg Harbor proper have been proposed. The one under which work is now being done was approved in 1887, and is as follows: To prevent the flow of water into the lake and make it a still-water basin in front of Vicksburg; then to dredge a basin in front of the town and a canal connecting this with the river.

The original plan, with its modifications and the history of the progress of the work, are given in the Reports of the Chief of Engineers from 1878 to 1889, inclusive.

The principal work done during the past year was the removal by dredging of 357,468 cubic yards of material, principally from the canal connecting the river and basin.

A detailed account of all the year's operations is given in the following report of Assistant Engineer Coppée, who was in local charge of the work:

REPORT OF MR. H. ST. L. COPPÉE, ASSISTANT ENGINEER, ON WORK DONE DURING THE YEAR ENDING MAY 31, 1890.

As stated in last year's report, the double-ladder Menge dredge was purchased from Joseph Menge, of New Orleans, and when that report was submitted she was on trial in the west end of Centennial Lake, Vicksburg Harbor. The dredge at that time did not work very satisfactorily, and owing to a defect in and breaking down of the scows we were unable to give it a fair test. Some slight changes were made in the machinery of the dredge at that time.

Early in June, as the water in the canal was sufficiently deep to operate the dredge, she was placed there, her chute being extended to one side, so as to throw the material well out on the bar; she was thus worked, the little material excavated being thrown to the bar side of the canal.

The reason for operating the dredge in this way was because the scows were unfit for use, until they could be strengthened and repaired, and we had no means of obtaining others with moderate expense.

A log of the work performed was sent to your office until July 10, when it was deemed expedient to close the work, as little good was being accomplished and the material placed on the bar would eventually have to be moved again.

The difficulty experienced with the dredge was the impossibility to keep her in line, the constant slipping of the rubber belts, thus failing to carry requisite power to the dredging parts proper, the rapidity with which the great friction on the crane tracks wore them out, the constant breaking of sprocket teeth, the bad working of the sprocket machinery in front for moving the dredge, and the small percentage of material moved.

The dredge was towed to the north end of Centennial Lake and laid up for the summer, cared for by a responsible watchman.

While running she was in the immediate charge of Mr. Hy. Steubing, who used every effort to work her successfully.

Since last summer, up to February of this year, owing to low water and other unfavorable conditions, no work of dredging was done in the harbor. Early last year a contract was entered into with the Alabama Dredging and Jetty Company, of Mobile, Ala., to dredge a canal and basin in front of the city, in accordance with plans and specifications submitted in former reports, for 10 cents and 12 cents per cubic yard, measured in scows, the latter price being for long haul around De Soto Island to north side of dam.

After the close of work at Greenville, I was ordered by Captain Leach to return to Vicksburgh, with a view to making the necessary repairs on the Menge dredge and placing her in commission, as the water had risen sufficiently at that point to warrant a commencement of excavating in the canal in front of the city. Some slight repairs were made, and the dredge was towed to the mouth of the south end of the canal. The rise proved but a temporary one, and the dredge worked with such poor success that I asked for instructions to be allowed to change the machinery in many respects and make numerous additions to her outfit.

December 21, the dredge was laid up for repairs. I will state here that Mr. Steubing urged the change of the sprocket machinery for moving forward, in the summer, but I had deferred doing so, with the hope that we could work it to better advantage after educating the crew, but this proved unsuccessful.

As soon as I returned here in December, I at once commenced, with the assistance of Mr. Charles Miller, assistant engineer, to establish the base lines of the former survey, to which all harbor-lines were referred. Soundings were made also, in order to obtain the changes that had taken place during the year and determine the material to be moved within the limits of our original cross-sections and within the means of the available appropriation.

After making the survey, I sent to your office the following estimate of material required to dredge the canal and basin to +6, +5, +4, +3, +2, +1, 0, and —5-foot planes on the gauge, showing the yardage as it existed last year and the additions for sloughing and fill during the year:

+6 feet on gauge:		
Canal and basin, 1889	cubic yards..	621,138.04
Add for fill during year	do....	39,405.80
Total for 1890	do....	660,543.84
+5 feet on gauge:		
Canal and basin, 1889	yards..	692,984.42
Add for fill	do....	39,584.83
Total for 1890	do....	732,569.25
+4 feet on gauge:		
Canal and basin, 1889	do....	767,258.23
Add for fill	do....	39,759.69
Total for 1890	do....	807,017.92
+3 feet on gauge:		
Canal and basin, 1889	do....	844,001.02
Add for fill	do....	39,975.13
Total for 1890	do....	883,976.15
+2 feet on gauge:		
Canal and basin, 1889	do....	923,181.96
Add for fill	do....	40,176.20
Total for 1890	do....	963,358.16
+1 foot on gauge:		
Canal and basin, 1889	do....	1,004,817.55
Add for fill	do....	40,374.38
Total for 1890	do....	1,045,191.93
0 on gauge:		
Canal and basin, 1889	do....	1,091,306.14
Add for fill during year	do....	40,550.40
Total for 1890	do....	1,131,856.63
—5 feet on gauge:		
Canal and basin, 1890	do....	1,561,091.55
Add for fill	do....	40,508.64
Total for 1890	do....	1,601,600.01

There was no appreciable fill in the basin, and the fill in the canal took place only in what constitutes the present channel, at the lower end (below range 52) where it was found to have extended over the entire bar, although very lightly.

The explanation of this lies in the fact that the river, during the season of 1889, scarcely came up over the surface of the ground west of the present canal, and then only for a short time, while it remained in the canal for quite a long time. Hardly an appreciable fill was detected at range 5, which was taken as 0, or the starting point. At range 15, the fill averaged about 6 feet, at range 25, it was about 1.2 feet, at range 35, 1 foot, at range 45, 1½ feet, and at range 50, 2.8 feet, at range 55, 3½ feet; below this it was very irregular, even showing a scour at some places, which is due to the fact that this part of the canal comes directly under the influence of the eddy water of the river. Since the date of these observations, the river has attained the highest point recorded since 1862. For over three months, since February 15, the water has been above 45 feet on the gauge, and above the crest of the pile-dam closing Lake Centennial. During this period, a current of considerable force has swept south along the city front, reversing the conditions that existed last year, tending to scour rather than fill in the line of the proposed canal and basin. The water has been too high, and remains too high at the present date, to make accurate observations in order to determine the extent of this change. The velocity of the current in the canal during this high water, has varied from one-fourth foot per second to 2 and 3 feet per second. The loose, soft material composing the surface of the bed of the canal, has been swept away.

At the beginning of the year I was notified that $79,000 was available for dredging in this harbor, $50,000 to be spent by the contractor at 12 cents and 10 cents per yard, measured in scows. For convenience in estimating, I take 11 cents per yard as the average, which is equivalent to 15 cents in place, approximately, when allowance is made for the expansion of material. The contractor could move, at that price, 340,000 cubic yards. Taking from the $29,000 left for working the Government plant, the following:

Survey	$534.00
Repairs to dike	1,050.52
Superintendent and inspectors, etc	700.00
Repairs and working Menge dredge	8,108.63
Purchase of tug *Parker*	6,500.00
Total	16,893.15

leaves a balance of about $12,000, and when office expenses and superintendence are deducted from this we have but about $11,000 for dredging with the Menge plant. This estimate is made to May 1, at 6 cents per yard, which is allowing for but 1,000 yards capacity per day, or half that guarantied by contractor; we have, say, 180,000 cubic yards, or 250,000 cubic yards moved by the combined plants. This will take us to the +8-foot plane.

I had anticipated dredging, at first, to the +7-foot plane, but so much expense has been incurred in repairs to the Menge dredge that that plane had to be abandoned. The $11,000 should insure work for four months with the Menge dredge, and remove, as stated, 160,000 cubic yards of material. This, of course, depends on the success in working the Menge dredge which, up to the present time, has proved anything but a successful machine.

February 24, the river being at a sufficient height, the contractor's dredge *Shelly* which had been sent from Mobile, Ala., in compliance with contract, was placed in line of canal, and commenced operations, working two watches, or twenty-four hours per day.

This dredge is a clam-shell digger, with 4-yard bucket, and a capacity of about 3,000 cubic yards in twenty-four hours; she has been working constantly and successfully up to the present time, moving the material from a depth equivalent to +12 feet on the gauge, it being impracticable to dredge to +8 feet in the present high water.

April 2, the *Herndon*, another of the contractor's dredges, commenced work, also in line of canal; the latter is the same dredge that worked here in previous years; a full description of which will be found in former reports; she is also a clam shell, but of greater capacity, being capable of moving 4,000 to 5,000 cubic yards in twenty-four hours. This dredge is working but one watch of about fourteen hours, but is moving as much material per month as the *Shelly* with double crew.

The material moved up to June 1 by these dredges, measured in scows, is as follows:

Herndon	cubic yards..	125,593
Shelly	do....	224,168
Total	do....	349,761

In the same time the following amount has been expended, $20,777.80, leaving a balance of $29,222.20 for the contract work.

Two inspectors on the *Shelly* and one on the *Herndon* are constantly employed by the Government, to keep a correct account of the material moved, and to see that the dredging is kept within the required cross-section; also a man is employed to see that each load on the long haul is dumped exactly along the line of the pile dam, in order to make a continuous earthen dike, as explained in former reports. If the rate of progress continues the same, it is probable that the contractor's work, to the full amount of the allotment of $50,000, will be completed early in July. In event of the passage of the river and harbor bill before that time, it would be greatly beneficial if an arrangement could be made by which the contract could be extended and the dredges kept at work, thus doing away with the necessity for further advertising and delays in making a new contract.

At the beginning of the year, before the water rose, it was proposed to repair the dam across the lake, where it had, owing to the rotting of the timber, broken down. Some piling braces and stringers were obtained for this purpose, also 22,000 feet, B. M., of lumber was purchased, but the river rose so rapidly that only a small part of the repair work was accomplished (115 piles were driven and braced). We have on hand now a few braces and stringers and a large part of the lumber. As the former will be but little loss if not used, and the latter could be used at other points (Greenville) for other purposes, and as the water will probably fall in a short time below the crest of the earth dumped along the dam, I would respectfully suggest that this repair work be abandoned until another year.

The plant in use here at the present time is as follows: One Menge dredge and outfit; two dump-scows, average each 200 yards; one tug, *Parker*; one quarter-boat, one barge, one pile-driver, two calking-flats, four skiffs, and one yawl.

The tug *Parker* was purchased at St. Louis during the first quarter, and has proved a very fine boat.

The contractors' plant consists of the following: One dredge, *Shelly*; one dredge, *Herndon*; four large scows, capacity averaging 475 yards each; two tugs, *Kaiser* and *Mannie*; four small boats.

Before giving the details of the work and repairs on the Menge dredge, it would be well to submit the following description of that machine:

The dredge (of the endless chain or ladder patent) was built by Joseph Menge, of New Orleans, La., in accordance with specifications accepted by Captain Rossell, in 1889, and is now the property of the United States Government. It is 95 feet long, 40-foot beam, 5 feet depth of hold, made of two barges, 15 feet beam each, with a 10-foot space between, forming a well for two bucket cranes. The two barges are held together transversely by six pieces of pine, 6 by 5 inches, on deck, with angle irons beneath; also, by three 1½-inch rods near stern, extending across the barges to outside. There are six braces between the barges, 6 by 12 inches by 10 feet long, butting against the outside, these braces having angle irons at each end, secured to sides of barges. Each barge has 8 by 14 inches lower gunwales, 4 by 16 inches tie braces (3 feet center to center) dove-tailed into gunwales, and six fore and aft keelsons 4 by 10 inches on edge, with tie braces pinned to same. The sides and ends are of 6 by 12 inch lumber, bolted with ¾-inch drift-bolts, 18-inch centers. There are 8 by 8 inch corner posts and 6 by 6-inch stanchions in hull, also, 3 by 12 inch bottom plank laid crosswise, fastened with ⅞ by 7 inch spikes. The beams are 4 by 8 inches, laid transversely, with 26-inch centers let into side 1½ inches and drift-bolted. The deck is 2 by 8 inch plank, fore and aft, secured with 30*d* nails. The middle keelson is 6 by 15 inches, running fore and aft, and pinned to 4 by 6 inch tie braces, with 4 by 4 inch studding between it and the deck-beams. Each barge has a square-built end aft, and rake forward built outside of the main body of the dredge. The hull outside and inside is well painted and saturated with creosote oil. There are two spud wells in dredge—one aft, the other forward of bucket-crane well, which occupies middle of dredge. Each spud well is lined at bottom and top with 4 by 1½ inch steel friction plates; the two spuds are made of four pieces of pine, well bolted together edgewise; the finished spud being lined with 3 by ⅝ inch steel bars, two to each side and one on each edge. The spuds are raised by a rack let into side of spud and pinion connected by gearing to steam-power in case of forward spud; the aft one to worm-gear worked by band. The lower end of each spud has a curved cast-iron cutter let into and secured to it to direct the motion of the dredge while working. Four pairs of 8 by 10 inch and two pairs of 8 by 10 inch uprights at the stern of the dredge, capped, braced, and securely fastened with bolts, receive the working parts of the dredging machinery and support the upper ends of the cranes, the hopper, and the delivery troughs. The latter are so arranged that the excavation can be delivered to right or left of dredge, or on both sides at once. This stern-frame is guyed or braced by fore and aft 1¼-inch hog-chains. A hinged chute extends from each side of frame-work, supported by derricks and hangers. A little forward of midships, a frame composed of two 10 by 10 inch uprights, with 10 by 12 inch cap pieces, two pair of 4 by 10 inch side braces, and two 8 by 8 inch aft braces, all securely bolted,

receive the crane-hoist shives. Also a saw-buck frame is situated midships, with the braces as far down as the oscillation of the crane will allow. Two cranes, 75 feet long each, made of 4¼ by 16 inch lumber, extend from stern frame-work through well, being fastened near lower end by heavy chains to hoisting frame. The frames have pine side guides 2 by 10 inch; tie braces 4 by 10 inches, and floor 2½ inches thick. Each crane oscillates from a point clear of the water-line to about 30 feet below the surface. At the stern of the dredge is located the cabins, kitchen, tool and store rooms, and all accommodations for crew and their subsistence. For working the dredge, moving the buckets, changing the position of inclination of the cranes, and moving the dredge forward, the following machinery is used on each barge, it being possible to work one or both cranes, as may be desired, and therefore one or both sets of machinery. Each barge has just aft of midships and in front of cabins, an Atlas engine 11 by 15 inches with reversing gear, and a 40 horse-power Atlas boiler complete, a duplex Worthington steam-pump with connections to bilge, to boiler, and to hose, with 2-inch suction and 1½-inch discharge. These large engines run a 4-ply 12-inch rubber belt connected with pulley, running shaft to which is geared a sprocket wheel, which sets in motion the endless-chain carrying buckets. There are two sprocket wheels each containing twenty eight sprocket teeth (on each side). There are four 42-inch idler wheels, regulating the position or sag of the buckets in the reversed condition. One steel shaft and one cutter wheel is fastened at lower end of each crane to cut up the material before it comes in contact with the bucket. There are thirty-five dredge-buckets on each pair of chains (approximate capacity of bucket, 3½ cubic feet). The buckets have bottom shell of ¼-inch iron, top shell ¼-inch steel, cutters 3½ by ½ inch steel, cross-bars 1¼-inch round iron. There are two tracks, 3 by ⅝ inch iron, on top of each crane incline, and two side-tracks, 2 by ¼ inch iron. The top tracks were originally steel, but wearing out in a short time were replaced by wrought-iron. One 8 horse-power donkey-engine is used on each side in hoisting-cranes by means of worm gear and heavy chain-drum. The chain (1⅛-inch proof) working through heavy shieves in forward frame and fastened to crane by two 3 by ½ inch iron hangers (hanger rods 2½-inch). The donkey-engines are also used in moving the dredge forward by sprocket chain-gear and spools on shafts, and also hoists the forward spud. The endless chains working over crane-track and idlers and through sprocket teeth, carrying buckets, two to each crane, are of 2 by ¾ inch Bessemer steel loops and links of round refined iron alternating, the link being square. A deck-pump is situated in front of laborers' quarters and just back of right-hand boiler, being used for pumping up boilers, cleaning, etc.

In order to dredge, the cranes are lowered to the required depth, the spuds let into the ground until the iron blades are well under the surface, and the large engines then put in motion. The cutters break up the hard material and the buckets take it up and carry it to top of crane, throwing it into the hopper at upper end. In turning to lower side of crane from the hopper, the material slides by its own weight into the troughs and thence into the dump-scow at side. This description is in part taken from the specifications, which were followed very accurately in building the dredge, and gives the condition before the numerous repairs and changes had been made.

It was not until we found it impossible to obtain good results, or, in fact, to do any work worth mentioning, that it was determined to make radical changes, but after our complete failure in December I recommended the changes, which were made, as follows:

The entire sprocket machinery at bow of boat for moving forward, which had proved very defective, and almost useless, was taken off of each side and replaced by two single-barrel steam capstans. The stern-spud was connected to small reversing engine. Plates were fastened to endless chains in order to relieve them of wearing by excessive friction. In addition to this, the roof was covered and heavily painted, and the dredge given two coats of paint. The two rubber belts (12 inches), which were entirely inadequate to carry the requisite power to the dredging machinery, were replaced by heavy patent link-leather belts. With these additions, the dredge was put to work and commenced digging March 25.

Her record was as follows:

Mar. 25.	Cubic yards measured in scows	100
26.	Cubic yards measured in scows	158
27.	Cubic yards measured in scows	90
28.	Cubic yards measured in scows	200
29.	Cubic yards measured in scows	109
Apr. 1.	Cubic yards measured in scows	200
3.	Cubic yards measured in scows	107
4.	Cubic yards measured in scows	165
5.	Cubic yards measured in scows	250
	Total cubic yards measured in scows	1,514

It was found during this time that the dredge was still imperfect in many respects, and she was laid up once more for changes and repairs. The beam carrying crane-

hangers has been increased in strength (four times). The entire hopper was remodeled and lowered to avoid losing a large percentage of material, as had been the case before. The bearings of main shaft, which were light and unreliable, were strengthened. The iron hangers were increased in size and section. A track and rollers have been placed on cranes, and runners rivetted to buckets to reduce the friction on endless chains and work of engines. This latter is an invention of Capt. Dan Kingman's, of the Engineer Corps, and is in use on his dredge at the mouth of Red River. A double-barrel steam capstan was placed at stern of dredge, to be used in hauling back in cut and regulating position by breast lines. Other small additions were made, and the dredge is now ready for work. It is hoped, with these changes, she will be able to move at least half the material for which she was designed. It will be impossible, as she has just commenced work, to make any extended record or estimate of her performance to accompany this report. Her record for the few days she has been operated is as follows:

May 14.	Cubic yards measured in scows	601
15.	Cubic yards measured in scows	287
16.	Cubic yards measured in scows	540
17.	Cubic yards measured in scows	305
19.	Cubic yards measured in scows	325
20.	Cubic yards measured in scows	427
21.	Cubic yards measured in scows	390
22.	Cubic yards measured in scows	151
	(Broke gear-wheel.)	
26.	Cubic yards measured in scows	652
27.	Cubic yards measured in scows	701
28.	Cubic yards measured in scows	320
29.	Cubic yards measured in scows	742
30.	Cubic yards measured in scows	182
31.	Cubic yards measured in scows	572
	Total cubic yards measured in scows	6,193

The original plan and history of the beginning and progress of the work on this harbor is given in former reports, dating from 1878 to the present time.

In regard to Delta Point, it will be impossible to make any report or estimate for repairs or new work.

Before the high water, early in the winter, the revetment was in comparatively good shape.

There was some caving in the reach above where Captain Russell recommended a large expenditure. What the high water has effected at that point, it will be impossible to state until the river reaches a much lower stage.

During the flood, which is just subsiding, we were called on a number of times to assist in protecting levees. I made a trip to the Raleigh Crevasse, at the request of the president of the fifth district, Louisiana Levee Board, and with the assistance of Mr. C. J. Coney, succeeded, in a very short time, with the aid of plant and laborers furnished by levee board, in stopping the caving at ends of break, by means of mattresses built of willow facines and rope, and sunk with sods of earth. This method, I believe, can be made successful where every other means fails. The tug *Parker* was used by the levee board for over two weeks, and we have endeavored to assist in every possible way, as you directed, in saving the levees and property endangered by the flood.

FINANCIAL STATEMENT.

Vicksburg Harbor.

Balance May 31, 1889		$108,205.73
Expended to June 30, 1890:		
Cost of plant, outfit, and repairs	$21,410.35	
Labor, repairs to dam and dike	450.17	
Material, repairs to dam and dike	904.98	
Subsistence	1,278.92	
Care of public property	559.18	
Dredging by United States plant	7,202.08	
Administration, inspection, and office expenses	3,215.79	
Dredging under contract	35,267.55	
Surveys	534.00	
Miscellaneous	76.96	
		70,899.98
Balance June 30, 1890		*37,305.75

*Fifteen thousand dollars of this amount reserved for repairs to Delta Point.

Of which:		
In treasury	$15,000.00	
On hand	22,305.75	
		$37,305.75
Less liabilities	4,806.17	
Less amount covered by existing contracts	11,296.06	
		16,102.23
Available balance June 30, 1890		*21,203.52
Amount that can be profitably expended in fiscal year ending June 30, 1892		175,000.00

Delta Point, Lousiana.

Balance May 31, 1889	$156.58
Balance in hand June 30, 1890	156.58
Available balance June 30, 1890	156.58
Amount that can be profitably expended in fiscal year ending June 30, 1892	150,000.00

GREENVILLE HARBOR.

The city of Greenville is situated in a deep, concave bend of the river, and is built entirely upon alluvial land. Rapid caving of the bank had been going on for some years, until a considerable portion of the business part of the town had been destroyed.

In the river and harbor act, approved August 5, 1886, a special allotment of $37,500 was made for preventing the bank at Greenville from further caving. The Mississippi River Commission decided, after an examination of the locality had been made, not to begin work here under this allotment, as the amount available was considered too small to warrant the inauguration of operations.

The city of Greenville subsequently placed $42,277.10 in the hands of the Commission for bank protection work. A project was thereupon prepared by the officer in charge of the district, which was duly approved by the Commission and carried out by the district officer, and which contemplated the building of ten sloping spurs along the city front, at intervals apart of about 500 feet, and similar in construction to those previously built at New Orleans and Memphis.

The results of the work were generally satisfactory, as pointed out on pages 2706, 2707, Annual Report of Chief of Engineers, 1889. The overfall over the dikes, however, produced a scouring effect between the dikes near the shore, which caused a slipping and caving of the bank between the dikes. The funds being practically exhausted, nothing could be done to prevent this until a further allotment should be made.

The river and harbor act, approved August 11, 1888, appropriated $75,000 for continuing work, in accordance with the plans and specifications of the Mississippi River Commission at Greenville, Miss. With the funds thus provided work was resumed, and during the year ending May 31, 1889, four mattresses were built and sunk along the bank between the dikes to prevent further caving there, and 706 feet of the bank along the foot of the island, immediately above Greenville, were revetted, as the rapid caving at this point threatened the improvement below.

A detailed report on the Greenville dikes by Assistant Engineer Hider is hereto appended.

The work done during the year ending May 31, 1889, is set forth in detail in the following report of Mr. H. St. L. Coppée, assistant engineer, who was in local charge of the work.

The high stage of the river has prevented the making of an examination of the work, so that its present condition and the improvement resulting from the work are unknown. The bank for several miles above Greenville is caving rapidly, and should be revetted, both for the general improvement of the river and for the protection of Greenville and its harbor.

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*Fifteen thousand dollars of this amount reserved for repairs to Delta Point.

REPORT OF MR. H. ST. L. COPPÉE, ASSISTANT ENGINEER, ON THE WORK DONE DURING THE YEAR ENDING MAY 31, 1890.

On being relieved of the Ashton work I was ordered to Greenville, to take charge of the repairs and new work contemplated at that point. The plant used for this work was: Two quarter-boats, one calking-flat, one pile-driver (used as bank grader with trough), two model barges, six square barges, two yawls, two skiffs, one steamboat, *Vidalia*.

For years the river-front of Greenville had been caving away, necessitating periodical moving back of the houses, and in fact of the entire town, to avoid being swallowed up by the ravenous water of the Mississippi River. The old town, established just after the war, and before the bank caving commenced, was situated over a mile west of the present site. The intervening land is now occupied by the bed of the Mississippi River, and at low water the Arkansas bank extends far over what was formerly the old Mississippi territory.

In order to regulate this part of the river, as well as protect the city front, the Mississippi River Commission commenced work in the fall of 1887; the plan being to stop the erosion of the bank by means of submerged spurs or sills, located 500 feet apart, resting on mattresses and extending beyond the deepest water or the channel line immediately next to the shore.

Ten dikes similar to that shown in Plate No. 1 were constructed in the fall and winter of that year, under the local direction of Mr. Arthur Hider, and they have proven very successful in checking the caving, and restoring a permanent front to the city of Greenville. (For detailed reports and maps of the work of 1887, see Report of Chief of Engineers, 1888, Part IV, page 2280.)

After the completion of the work of 1887, or during the low-water of 1888, a survey demonstrated the fact that extensive caving had taken place in the bend above the immediate city front and along the island that threatened the system of dikes.

A mattress 706 feet by 250 feet was built and sunk in position, and the upper bank revetment completed just above the island, in the winter of 1888. (See Report of the Chief of Engineers, 1880, page 2707.

This latter mat and revetment was badly broken up, and the face of the island was caving when work was ordered to be done in August, 1889. Captain Rossell at first contemplated building three submerged (crib) spur-dikes in the positions marked A, B, and C on the map, but owing to scarcity of funds and change of plans, the point A was protected by a pile-dike 200 feet above the upper or last dike of the system built in 1887. The other dikes A and B were built 500 feet apart, the latter being located on the mattress sunk in the winter of 1888–'89.

The work under my charge was simply the extension up the river of the original system of dikes, to stop the caving that had occurred recently above the other protection works.

More in detail, the work consists of cribs forming two dikes built of willows, wire, and stone, constructed at an interval of 500 feet in length of bank, and reaching out beyond the deepest water in the channel of the river next the shore. The purpose they are expected to serve, as stated before, is the protection of the bank immediately at the point they occupy, and the indirect protection of the intermediate spaces by deposit, due to the eddy and dead water formed by their position out in the swift current of the river. Each dike was constructed as follows: The sites of the proposed mattresses and cribs having been selected, and soundings having been made, to define the profile of the bank and the distance to the channel, or, in other words, an accurate hydrographical survey having been made of the locality, a mattress was built at B, 290 feet long by 290 feet wide, extending about 50 feet beyond the channel line. At C one was built 250 feet long by 275 feet wide. The mattresses were constructed on floating ways of willow, brush, and poles, wire and spikes, and as woven launched off into the river; when finished and all afloat, and all necessary lines and cables fastened to the shore, they were sunk into place on the submerged bank, with rock wheeled and thrown from barges. The mattress acts as the foundation of the cribs which form the dike. The dimensions and general form of cribs is governed by the profile of the bank immediately at the points where it is proposed to build the dike. At B and C, Plate 1, cribs were built of uniform section; in each case the dike being composed of two cribs. In Dike No. 1, or C, the lower crib was 240 feet long, 32 feet wide, and 8 feet high the upper one 190 feet long, 16 feet wide, and 6 feet high. At Dike No. 2 (B), the lower crib was 212 feet long, 32 feet wide, and 8 feet high; the upper one 170 feet long, 16 feet wide, and 8 feet high. The center of Dike No. 1 averages 90 feet below the up-stream edge of foundation mattress, and center of Dike No. 2, 90 feet below up-stream edge of its mattress.

The dikes are finished with a uniform surface as nearly as possible, and a slope of from 4 to 1, to 5 to 1, from river end to top of graded bank. As a rule, in this work the crib is a right rectangular prism, the top one having a base of 16 feet and depth of 8 feet, with variable length depending on conditions existing in bank and

channel lines; the next one below is 32 feet by 8 feet by variable length; the next, 48 feet by 8 feet, and so on, each one below in the series being 16 feet wider than the one immediately above. As a general rule, also, three cribs form the dike, but, as before stated in this work, but two were constructed in each dike. Each crib was constructed as follows: A frame-work of poles and willows laid with 8 feet squares was built of the required length and breadth, on its layers of brush, both longitudinal and transverse, were laid, and again another frame, and so on, until the crib was about 3 feet in depth. These frames and intermediate layers of brush were thoroughly sewed together with No. 12 wire and 9-inch spikes; wire being left projecting far above the last frame to fasten the lower to the upper crib-work. Up to this point the crib was built on floating ways, but was then launched into the river at the place where it was proposed to sink it. It was fastened by lines to mooring barges that held it in place, and also fastened to the shore by shackle lines (2-inch manilla rope) leading well up the river, also holding it in place while sinking.

At the intersection of the frame poles, 8 feet apart, upright posts 9 feet high were securely fastened, and to these, as well as the lower frame, a crib was built, pockets being constructed in each 8-foot square, the shape of an inverted frustrum of a pyramid, by dropping back one pole as each layer was laid above the bottom frame. When finished the crib was from 6 to 8 feet deep, with pockets 8 feet from center to center, each capable of holding, approximately, 3 cubic yards of rock. The whole crib, like the lower frame, was securely fastened throughout with spikes, wire, and cable. The sinking of the crib was as follows: after it was securely fastened to the bank by cables, having been placed over the desired location, and after being checked up well by slip lines to the mooring barges, rock was thrown into the pockets until they were filled. When the weight had much more than overcome the buoyancy of the structure the strain on the lines was very great and the crib in a sinking condition; then the slip lines were rendered slowly, care being taken to keep the strain uniform till the crib settled in its place on the mattress. In the case of the second or top crib, it was built 16 feet narrower as above stated, and sunk in the same manner, but on top of the first one, thus forming a sill 16 feet high. After the construction of the mattress the portion of the bank (at the site of the dike) above the water line was graded to a slope of 4 to 1, preparatory to covering it with a revetment of willow and stone, which was connected with the submerged mat.

The grading was done with shovels, the material being thrown into troughs laid on the required slope (as a guide), through which a constant stream of water was forced from a pump on a floating pile-driver; thus each shovelful taken from the face of the crib was cast but once, and carried by the force of the water into the river. The cost of moving the earth in this manner was from 6 to 8 cents per cubic yard, depending upon the consistency of the material forming the bank, which ranged from loose, sandy loam to the toughest kind of blue clay and buck-shot.

After completing the grading the revetment was laid; first, a frame-work of poles in 8-foot squares; then two diagonal layers of brush placed on the frame; then a corresponding frame-work to that below placed on top, and the entire mass fastened together securely with wire and spikes; on this stone was placed so close as to hide the top layer of brush. When the revetment was finished and mattress and cribs sunk, the upper end of the partly submerged crib-work was joined to the top of the bank, the work being accomplished on the ground, the construction otherwise being the same, and the pockets filled with rock as in the case of the submerged work. Great trouble was experienced during the progress of this work in obtaining sufficient reliable labor.

The accompanying abstract and estimate of labor and material gives the details of dimensions, composition, and cost of this work. The great variation in the amount of material and labor expended is due to the (before mentioned) irregular and unreliable labor, the different conditions in stage of river, etc., and slight changes in details of construction. About September 15 considerable difficulty in construction was caused by the rising river and large quantities of floating drift; but, though the work was considerably retarded and the cost increased, no actual loss was sustained.

For this work brush was obtained from Elisha Evins, at 1.27½ per cord; poles from the same party, at $1.47½ per cord; and stone from Gottlieb Hartweg, at $1.50 per ton. October 30 the work on these two dikes was practically completed, and as there were certain repairs ordered by the Commission at Bolivar, Miss., which it was necessary to make at low water, I was instructed to move the plant to that point, and do the necessary work there before the winter rise should take place.

The amount of money spent up to that time was $24,037.76 for the two dikes, or say $12,000 apiece. This is considerably in excess of what it would be under more favorable circumstances.

November the 26th, the repair work at Bolivar being completed, the plant was again moved to Greenville.

At first it was proposed to build at A (see map) a crib-dike similar to those constructed during September and October, but owing to scarcity of funds, and also to

the fact that Captain Leach, who was then in charge of the third district, thought a pile-dike, which would be much less expensive, would answer the same purpose, and as well carry out the plans of the Commission, he ordered such a structure to be erected. The material for this work was in great part brought from Bolivar, and part obtained by Government labor. The dike, as shown on map, was constructed by first sinking in the pocket a mattress 270 feet long by 100 feet wide, and through it driving, as shown, two rows of cottonwood piling, the piles in each row being about 8 feet apart and the rows 20 feet apart; the piles being all connected by double, horizontal bracing, one system near top of piling and the other about 10 feet below. The inner or land row of piling was closely wattled with willow brush, and the ends of the dike fastened well into the bank. This completed the season's work at Greenville, and leaves an unprotected space of river front from the pile-dike to Dike No. 2 along face of island of about 1,500 feet, which by all means should be protected as soon as funds are available for that work; also above Dike No. 1 the bank should be protected for a long distance to stop the caving, which would ultimately endanger the work below. For exact cost and plan of operations see Mr. Hider's report to General Comstock, president of the Commission, made March 30, 1890. He recommends as follows:

Three more dikes to complete system	$30,000
5,000 linear feet of revetment, at $43	215,000
	245,000

The work was practically finished December 16, 1889, and the property left in charge of Mr. C. J. Coney, foreman, until such time as the balance of the fleet should be moved to Greenville.

REPORT OF ASSISTANT ENGINEER ARTHUR HIDER ON THE GREENVILLE DIKES.

LOUISIANA BEND, LA., *November* 30, 1889.

SIR: In compliance with instructions contained in your letter to Capt. Wm. T. Rossell, October 11, which he referred to me on October 16, directing a "report of the general conclusions to be drawn from the Greenville dikes as to their permanence, their effect, their success, and final cost, the following is respectfully submitted:

The data upon which this report is based is derived from comparison of surveys of the locality showing the condition of the dikes from time to time, and from examination at irregular intervals of such parts of the work as were exposed above water.

For a number of years the caving in front of the town has been very rapid. A survey was made in August, 1884, with the view of improving the front, but no work was done at that time. The next survey was that of August, 1887, which was made with the object of properly locating the spur-dikes that were ordered built by the Commission. During this interval of three years the rapid caving of the front had continued, one whole street (Mulberry street, parallel with the river), that contained the principal business houses, had caved away.

	Feet.
At Percy avenue the bank had caved back	400
At Central avenue the bank had caved back	390
At Main street the bank had caved back	640
At Washington avenue the bank had caved back	480
At Davis street the bank had caved back	510

An average distance of 464 feet, and an average yearly rate of 154 feet.

The survey of August, 1887, showed that the location of the dikes would give the best results by placing them about equidistant along the front of the business part of the town. The dikes were therefore located, beginning at Range 4½, at intervals of 500 feet, except the two lowest ones, Dike 12½ and 13½; these were spaced somewhat farther apart, so as to protect the bank at the lowest point, where caving had taken place the previous season.

These dikes had for foundations substantial willow mattresses, extending 200 feet along the bank and out into the river, beyond the zero line from 280 to 420 feet. The dikes were built of willow brush and of cottonwood and willow poles; the top cribs were 16 feet wide, except Dike 4½, which consisted of a single crib 24 feet wide, the cribs increasing in width to 32 and 48 feet at the bottom, where the dike consisted of two or three tiers of cribs, as the case might be. The foundation mattresses in all cases extended out in the river beyond the deepest water; the brush, revetment and the crib-work was continued up to the top of the bank, and this revetment afterwards covered with stone. In lowering the upper cribs to their place great care was taken to have them rest on those below.

The cribs were from 6 to 8 feet deep, and the dikes themselves, when finished, varied

from 6 to 24 feet in height, depending on the number of cribs used. The dikes had an approximately uniform slope from their outer ends to the top of the bank. Ten of these dikes were built, covering about 5,000 linear feet of bank, the work beginning September 16, 1887, and ending January 20, 1888. While the work was in progress, caving took place at Range 10½ and Range 11, but as soon as the foundation mats were in place it ceased at both these points.

On December 29, more than a month after Dike 8½ was finished, a cave occurred just above it, undermining the revetment on the upper slope; an extra mat was built in front of this, and no further caving took place. These slips were undoubtedly due to previous undermining of the bank, as indicated on top of the bank by cracks while the work was in progress. The work stood the ensuing high water and the subsequent fall until late in July, 1889, without showing any break or cave, when sloughing of the bank between the dikes began, and continued during the low-water season from August to November.

A survey was made October, 1888, to determine what the effect of the dikes on the front had been; this survey showed that in every case, except at the extreme ends of the system, there had been eddy action immediately below the spurs, and that the first effect of the dikes had been to induce a scour between them next the shore, and thus cause a slip or cave in the bank between the spurs. This slipping of the bank was from Ranges 6½ to 7½, 7½ to 8½, 8½ to 9½, 9½ to 10½, 10½ to 11½, and just below Dike 14.

At the same time, at Dikes 4¼, 5½, and 6½, there was a considerable deposit. This deposit extended up the slope to within 10 or 15 feet of the top of bank, entirely covering the revetment and cribs in places; at Dike 10½ there was also a deposit from 3 to 4 feet deep on the lower half of the revetment. At the other dikes there was no deposit. There was a slight breaking down of the lower end of the upper revetment at dikes 8½, 10½, and 13½, due to undermining of the bank.

The above was the condition of the work when repairs began December 11, 1888. These repairs consisted of three mattresses 185 feet wide, built where the greatest caving had occurred, viz, between Dikes 8½, 9½, 9½ to 10½, 12½ and 13¼; a small mat was put in below Range 13½. The mats lapped those already built, with upper-bank protection, extending as high as could well be done without an excessive amount of grading. The repairs were finished January 31, 1888. At the present writing the work is in good condition; the repairs made seem to have accomplished the object for which they were intended, as no further caving has taken place and the work is intact.

Comparing the survey of August, 1887, made just before the dikes were constructed, with that made in October, 1888, shows that there was a scour between the dikes, as indicated by the changes in position of the 30-feet contour nearest the Mississippi shore, which moved in towards the shore.

Between Dikes 4½ and 5½, on Range 5, the contour moved out 60 feet.
Between Dikes 5½ and 6½, on Range 6, the contour moved in 150 feet.
Between Dikes 6½ and 7½, on Range 7, the contour moved in 30 feet.
Between Dikes 7½ and 8½, on Range 8, the contour moved in 30 feet.
Between Dikes 8½ and 9½, on Range 9, the contour moved in 25 feet.
Between Dikes 9½ and 10½, on Range 10, the contour moved in 30 feet.
Between Dikes 10½ and 11½, on Range 11, the contour moved in 40 feet.
Between Dikes 11½ and 12½, on Range 12, the contour moved in 170 feet.
Between Dikes 12½ and 13½, on Range 13, the contour moved out 80 feet.
Below Dike 13½, Range 14, the contour moved out 90 feet.

Again, comparing the survey of October, 1888, with that of January, 1889, shows that the 30-foot contour moved out again in the mean time between seven of the ten dikes, as the effect of the second high water, as follows:

Between Dikes 4½ and 5½, on Range 5, the contour moved out 60 feet.
Between Dikes 5½ and 6½, on Range 6, the contour moved in 20 feet.
Between Dikes 6½ and 7½, on Range 7, the contour moved out 10 feet.
Between Dikes 7½ and 8½, on Range 8, the contour moved out 60 feet.
Between Dikes 8½ and 9½, on Range 9, the contour moved in 80 feet.
Between Dikes 9½ and 10½, on Range 10, the contour moved out.
Between Dikes 10½ and 11½, on Range 11, the contour moved out 55 feet.
Between Dikes 11½ and 12½, on Range 12, the contour moved out 40 feet.
Between Dikes 12½ and 13½, on Range 13, the contour moved in 15 feet.
Below Dike 13½, on Range 14, the contour moved out 40 feet.

In this connection attention is called to the fact that after the dikes had successfully withstood the effects of the first high water the filling up of the pockets between the dikes with sediment took place, not only where the extra mats were sunk to prevent further caving, but below the other dikes also, between which no mats had been placed. This would seem to indicate that, although the first effect of the spurs was to induce a scour immediately below them, the resistance that they exerted to the eroding action of the current caused the maximum effect of the current impinging against the bank to exert itself gradually further out, thus inducing a fill or deposit

immediately below each dike which had at first scoured out, a shifting of the deep-water line farther away from the protected bank, and a corresponding movement of the channel towards the opposite shore.

Comparing the survey of August, 1887, with that of October–November, 1889, shows that the above is the case.

	Feet.
The west 30 feet contour, opposite—	
Range 5, moved in	20
Range 6, moved in	35
Range 7, moved out	20
Range 8, moved out	135
Range 9, moved out	280
While the line of deepest water, opposite—	
Range 5, moved out	485
Range 6, moved out	50
Range 7, moved out	65
Range 8, moved in	35
Range 9, moved in.	

	Feet.
The west 30 feet contour, opposite—	
Range 10, moved out	245
Range 11, moved out	165
Range 12, moved out	195
Range 13, moved out	295
Range 14, moved out	230
While the line of deepest water, opposite—	
Range 10, moved in	90
Range 11, moved in.	
Range 12, moved out	115
Range 13, moved out.	
Range 14, moved out.	50

An examination of the soundings taken in January, May, and October, 1889, shows a general settlement of all the cribs, and at the same time a fill over the foundation mat immediately below. The October soundings show an after fill over Dikes 7½ and 8½. Part of this settlement is undoubtedly due to compression of the willow brush and poles, of which the cribs were constructed, and the rest to scour. The survey of October, 1889, shows that all the cribs are in place.

The maximum height above the foundation mat to the top of the cribs was found from 80 to 120 feet beyond the zero line, and at a point from 225 to 250 feet beyond the zero line; the height of the cribs above the bottom decreased to zero. The average height of the ten cribs above the foundation mats at the deepest points was 15 feet. The profiles indicate a scour at these points below the general level of the bottom. As this may be considered the foot of the upper bank slope, it is important, to insure stability to the work, that no scour should take place here. The advisability of lower cribs at this point gradually decreasing in height to the level of the foundation mat 150 feet farther out, suggests itself from a careful examination of the profiles as likely to give better results than cribs of greater height, for the reason that both the overpour and eddy action would be less.

As to the permanence of the improvement; from a careful examination of the locality and its present condition, I see no reason why the dikes may not be considered as permanent as could be expected of this class of work, provided that the system is extended up-stream, or other improvements made which will prevent the dikes being destroyed, from cutting back and working down of the bend below. The effect of the dikes has undoubtedly been to hold the river front, and to gradually shift the deep water away from the protected shore. The success of the work has given a new impetus to business in the town, and the money spent by the citizens on the improvement has already been returned to them in increased value of property. New business enterprises have sprung up, and a general feeling of confidence in the stability of the improvement prevails.

Final cost.—The original cost of the ten dikes was about $10,000 for each dike. To extend the system to connect with the two dikes finished this season, three additional dikes should be built, and above this 5,000 linear feet of revetment will be required to protect the caving bend, so as to render the improvement complete and permanent. These mattresses should extend out 300 feet beyond low water. A modified plan for this work, combining the continuous revetment and low spurs, is submitted herewith, and an approximate estimate of cost. The estimated final cost of completing the improvement of Greenville Harbor on the plan proposed, is as follows:

Cost of ten dikes built in 1887	$101,011.03
Repairs to same and mattresses at head of Island 93, 1888	39,565.78
Cost of two dikes built in 1889, about	24,000.00
Cost of three more dikes to complete system	30,000.00
5,000 linear feet of revetment on the proposed plan, at $43	215,000.00
Total estimated final cost	409,576.81

PROPOSED PLAN FOR BANK REVETMENT.

The following modification of the plan heretofore followed in protecting caving banks, or, more properly, a combination of the continuous mattress revetment and

spur-dike system, suggests itself from an examination of the effects of the Greenville dikes, and from experience in executing both of these classes of work at other localities.

The main advantages are—

First. Extra strength at the foot of the upper slope, where the undermining of the bank begins.

Second. Utilizing the overlapping of the main mattresses as a foundation for the dikes.

Third. Constructing the dikes as part of the main mattress, and with such profiles as from a study of Greenville dikes promise the best results.

Fourth. Saving of stone on the extreme upper part of the slope.

Fifth. Thoroughness of work and method of procedure, allowing the greatest amount of work to be done during low water.

DESCRIPTION OF THE PROPOSED PLAN.

First. To grade the upper bank to a slope of 1 on 3½ or 4 before any mat building is done.

Second. To build a shore-mat reaching up the slope to about 15 feet stage, and extending out in the river to, say, 50 feet beyond the low water-line. Should the stage of water, after the bank has been graded, be too low to allow this to be done, a revetment of brush to be carried up to the proper height as part of the shore-mat. This shore-mat, or shore-mat and brush revetment, to be 100 feet wide, and to be finished before the building of the main mattress begins.

Third. After the shore-mat is in place, to construct the main mattress, extending 300 feet out from the low water line, the inner edge resting on the shore-mat already in position. This main mat to be built in sections of 550 feet, and to be secured by ⅝-inch cables to fastenings on top of the bank, the upper and lower 50 feet to be cribbed up with poles, so as to form the foundation of the dikes, each mat to overlap the upper one 50 feet. In the middle of this foundation a low dike is to be built 16 feet wide, 6 feet high, at a point 100 feet beyond the zero line, and decreasing in height both ways from this central point to zero at the inner edge of the mat, and at a point 250 feet further out. This dike to form a part of the head of each mat, as shown on plan.

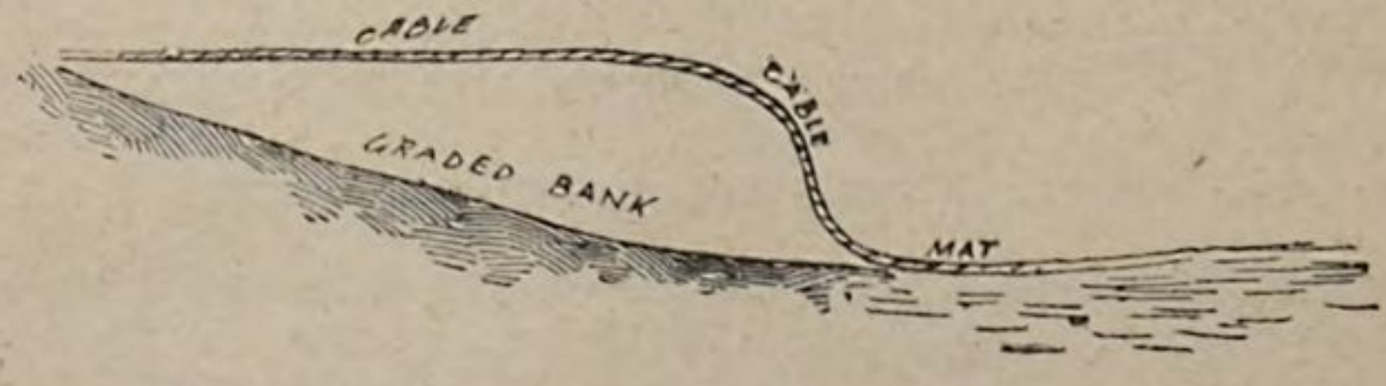
Fourth. From low-water line to within 5 feet measured vertically from the top of the bank, the upper slope to be covered with stone 10 inches thick.

The following are some of the advantages of the method proposed:

The grading of the upper bank before any mat building is done suggests itself from practical difficulties that arise in grading the high banks after the mattresses are in place. The material of which the banks are composed is not uniform, loam, clay, buckshot, and silt occurring in layers one above the other; frequently for a distance the bank is entirely of sand, and at other places silt; especially is this silt found in pockets between points of harder material jetting out from the shore. The result where hydraulic grading is the method practiced is a washing out of the lower part of the slope in holes where composed of sand or silt, breaking down of the outside edge of the grade, and sloughing off next the water. In order not to retard the progress of the work, these holes are necessarily filled up with loose material, with no time for settlement.

Again, the great quantity of water pouring down the slope thoroughly saturates the lower part, and leaves it in anything but a proper condition as a foundation for riprap.

The banks in many places are 30 feet or more in height, with an irregular face, approximating 1 on 1. The cables which are woven in the mat, and pass over the top of the bank where the mat is sunk, become loose as the grading proceeds, and afford no resistance to the sliding out of the mat, at a time when it is subjected to an enormous strain from the slipping down under the mat of the material that is washed from the bank in a semi-fluid condition. These cables can not be kept taut while the grading at the particular point is in progress, and the result the present season has been, where the material was soft, a sliding out of the mat and parting of the cables. This necessitates the building of new mats, adding materially to the cost of the work. The diagram below will perhaps explain more clearly.



These are the principal practical objections to grading the upper slope after the mat is sunk in place, aside from the fact that this plan of work shortens the time when revetment work can be properly done. Inasmuch as the low-water season is of short duration, and it is only at low stage that grading of the upper bank can be carried on, the amount of revetment work that can be finished depends upon the length of upper bank that it is possible to grade before the river rises. And as the grading is necessarily the length of one mat, from 800 to 1,000 feet, behind (by reason of the space occupied by the head and mooring lines to the lower mat under construction), it is compulsory to stop mat building before the river begins to rise to any extent, in order to have sufficient time to grade and revet the slope in front of the last mat, or else leave this part of the work in an unfinished condition with the lower part of the bank slope nearly vertical.

Among the advantages of grading ahead of the mat construction are:

First. The graded bank allows the holding in cables to be permanently fastened before the mat is sunk in place, thus preventing any slipping or sliding out of the mat from the shore.

Second. The whole of the low-water season can be utilized for work in mat building; the mat construction and bank revetment can be carried up the graded slope as the river rises, thus allowing more work to be accomplished.

Third. It provides a regular slope for the upper part of the shore mat to rest on or for the brush revetment to be placed, which, covering the loose material with which the holes in the lower slope made in grading are filled, gives the stone with which the slope is covered when completed a better support, and prevents it sinking into the soft earth.

Fourth. It insures better work.

GENERAL REMARKS.

The weakest part of revetment work is at or near the low-water line. By the construction of a shore mat as proposed, a double thickness of mattress is placed at the point where a break in the work might be anticipated, and strength therefore most needed, besides affording a foundation for the stone on the lower part of the slope, where the material is saturated and soft. The overlapping of the main mattresses on the shore mats forms a footing or abutting course, as it were, to prevent the slipping of the stone down the revetment below the low-water line.

The cribbing up of the upper and lower ends of the main mattress as a foundation, and the constructing of the low dikes at the foot of the slope, can be readily and economically done while the mat building is going on.

From a careful examination of the profiles of the Greenville dikes, and a number of sections in caving bends, it is believed that at the point where the grade of the river bottoms changes to the more abrupt grade of the caving bank, a system of low dikes of the profile proposed would have a good effect.

There is always danger, to a greater or lesser extent, in building and sinking mats 300 or 350 feet wide in a rapid current, where the length exceeds 500 or 600 feet. The length of the proposed mats is within these limits, and under ordinary circumstances there should be absolutely no danger of loss.

Leaving out the riprap on the upper 20 feet of the slope would save for a mile of work about 3,260 cubic yards of stone; taking cost of this at $2.50 per cubic yard and the cost of placing same at 40 cents, the total saving per mile would be $15,312.*

There can be no possible danger to the stability of the work in leaving this part of the bank unprotected, provided that the lower part of the slope is held; as the result of wave-wash would merely bring the slope to a water grade, and caving above this point, even if the bank was left vertical, could do no injury to the revetment underneath it.

More work can be accomplished by doing the grading first, while at the same time it will be left in a finished condition at the end of the working season.

The general results to be anticipated from revetment constructed as above would be due to a series of low dikes placed 500 feet apart, extending 250 feet beyond low water, with a continuous mattress between them. The upper slope covered with riprap 10 inches thick to within 5 feet of the top of the bank, and a double thickness of mattress extending from the zero line to a point 50 feet beyond. It is believed that this constructing will hold the bank in the worst caving bends.

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* This should be $9,454. (C. B. C.)

An approximate estimate of cost is given below for each 1,000 linear feet of completed work:

3,400 cords brush, at $1.10	$3,740.00
650 cords poles, at $1.50	975.00
6,450 cubic yards stone, at $2.50	16,125.00
26,000 pounds ⅝ inch wire cable, at 4 cents	1,170.00
3,0000 pounds wire, at 4 cents	1,200.00
8,000 pounds spikes and staples, at 4 cents	320.00
	23,530.00
Cost of labor and towing estimated at 40 per cent. of cost of work	15,686.66
	39,216.66
10 per cent. added for contingencies	3,921.66
Total estimate cost	43,138.32
Cost per linear foot of completed work	43.00
Cost per mile of completed work	227,040.00

Estimate of actual cost of material, labor, and subsistence in building crib-dikes at Greenville, Mississippi, September and October, 1889.

DIKE No. 1.

[Foot mat No. 1, 250 feet long by 175 feet wide = 43,750 square feet.]

Item.	Cost per unit.	Cost.	Per 100 square or cubic feet.	
			Item.	Cost.
Brush, 400 cords	$1.27½	$510.00	0.914 cord	$1.17
Poles, 27 cords	1.47½	98.82	0.513 cord	.23
Stone, 708 tons	1.50	1,062.00	1.616 tons	2.43
Wire, 40 coils	3.37	134.80	0.091 cord	.31
Cable, 7½ coils	42.27	317.02	0.017 cord	.72
Spikes, 6-inch, 2 kegs	3.25	6.50		
Spikes, 9-inch, 6½ kegs	3.12½	20.31	0.019 keg	.06
Staples, 1 keg	5.00	5.00	0.002 keg	.01
Total		2,154.45		4.93
Construction, 4,068 hours	.17	*691.56	9.30 hours	1.58
Sailor work, 1,827 hours	.17	*310.59	4.18 hours	.71
Total		1,002.15		2.29
Grand total		3,156.60		7.22

* Including subsistence.

[First crib, 240 feet long by 32 feet wide by 8 feet high = 61,440 cubic feet.]

Brush, 184 cords	1.27½	234.60	0.299 cord	.38
Poles, 165 cords	1.47½	243.37	0.268 cord	.40
Stone, 378½ tons	1.50	567.75	0.616 ton	.92
Wire, 37 coils	3.37	124.69	0.060 coil	.20
Cable, 3½ coils	42.27	147.94	0.006 coil	.24
Spikes, 6-inch, 1 keg	3.25	3.25		
Spikes, 9-inch, 10 kegs	3.12½	31.25	0.018 keg	.06
Staples, ½ keg	5.00	2.50	0.001 keg	.00
Total		1,355.35		2.20
Construction, 2,932 hours	.17	*498.44	4.77 hours	.81
Sailor work, 999 hours	.17	*169.83	1.62 hours	.27
Total		†668.27		1.08
Grand total		2,023.62		3.28

* Including subsistence.

† Owing to high water running, drift, and unreliable labor, this is much in excess of what it should be.

Estimate of actual cost of material, labor, and subsistence, etc.—Continued.

DIKE No. 1.—Continued.

[Second crib, 190 feet long by 16 feet wide by 6 feet high = 18,240 cubic feet.]

Item.	Cost per unit.	Cost.	Per 100 square or cubic feet.	
			Item.	Cost.
Brush, 64 cords	1.27½	81.60	0.351 cord	.45
Poles, 63 cords	1.47½	92.92	0.345 cord	.51
Stone, 102⅔ tons	1.50	153.75	0.562 ton	.84
Wire, 25 coils	3 37	84.25	0.137 coil	.46
Cable, 2 coils	42.27	84.54	0.011 coil	.46
Spikes, 6-inch, 1 keg	3.25	3.25		
Spikes, 9-inch, 6 kegs	3.12½	18.75	0.038 keg	.12
Total		519.06		2.84
Construction, 1,331 hours	.17	*226.27	7.30 hours	1.24
Sailor work, 582 hours	.17	98.94	3.19 hours	.54
Total		325.21		1.78
Grand total		844.27		4.62

*Including subsistence.

[Revetment No. 1, 25,000 square feet.]

Brush, 318 cords	1.27½	405.45	1.272 cord	1.62
Poles, 51 cords	1.47½	75.22	0.204 cord	.30
Stone, 710 tons	1.50	1,065.00	2.840 tons	4.26
Wire, 27 coils	3.37	90.99	0.108 coil	.36
Spikes, 5 kegs	3.12½	15.62	0.020 keg	.06
Total		1,652.28		6.60
Construction, 3,281 hours	.17	*557.77	13.12 hours	2.23
Grading, 878 hours	.17	149.26	3.51 hours	.60
Total		*707.03		2.83
Grand total		2,459.31		9.43

*Including subsistence.

[Spur No. 1, 20,000 cubic feet.]

Brush, 45 cords	1.09	49.05	0.225 cord	.25
Poles, 85 cords	1.48	125.80	0.425 cord	.63
Stone, 97 tons	1.95	189.15	0.485 ton	.95
Wire, 10 coils	3.37	33.70	0.050 coil	.17
Total		397.70		2.00
Construction, 707 hours	0.17	*120.19	3.53 hours	.61
Grand total		517.89		2.61
Cost of entire dike No. 1		9,001.69		

*Including subsistence.

Estimate of actual cost of material, labor, and subsistence, etc.—Continued.

DIKE No. 2.

[Foot mat No. 2, 290 feet long by 290 feet wide = 84,100 square feet.]

Item.	Cost per unit.	Cost.	Per 100 square or cubic feet.	
			Item.	Cost.
Brush, 553 cords	1.27½	705.07	0.657 cord	.84
Piles, 141 cords	1.47½	207.97	0.168 cord	.25
Stone, 767 tons	1.95	1,496.65	0.912 ton	1.78
Wire, 34 coils	3.37	114.58	0.040 cord	1.36
Cable, 6 coils	42.27	253.62	0.007 cord	.30
Spikes, 6-inch, 4 kegs	3.25	13.00		
Spikes, 9-inch, 5½ kegs	3.12½	15.63	0.011 keg	.03
Staples, 1¼ kegs	5.00	6.25	0.001 keg	.01
Total		2,811.77		4.57
Construction, 5,630 hours	.16	*900.80	6.69 hours	1.07
Sailor work, 737 hours	.16	*117.92	0.88 hour	.14
Total		1,018.72		1.21
Grand total		3,830.49		5.78

*Including subsistence.

[First crib, 212 feet long by 32 feet wide by 8 feet high = 54,272 cubic feet.]

Brush, 228 cords	1.27½	290.70	0.420 cord	.54
Poles, 100 cords	1.48	148.00	0.184 cord	.27
Stone, 324 tons	1.50	486.00	0.597 ton	.90
Wire, 32 coils	3.37	107.84	0.059 cord	.20
Cable, 2½ coils	42.27	105.67	0.005 cord	.20
Spikes, 6-inch, 2¾ kegs	3.25	8.94		
Spikes, 9-inch, 7¾ kegs	3.12½	24.22	0.019 keg	.06
Total		1,171.37		2.17
Construction, 2,686 hours	.16	*429.76	4.95 hours	.79
Sailor work, 610 hours	.16	*97.60	1.12 hours	.18
Total		527.36		.97
Grand total		1,698.73		3.14

*Including subsistence.

[Second crib, 170 feet long by 16 feet wide by 8 feet high = 21,760 cubic feet.]

Brush, 95 cords	1.27½	121.12	0.437 cord	.55
Poles, 52 cords	1.48	76.96	0.239 cord	.35
Stone, 119 tons	1.95	232.05	0.547 ton	1.07
Wire, 27 coils	3.37	90.99	0.124 coil	.42
Cable, 1½ coils	42.27	63.40	0.007 coil	.29
Spikes, 6 inch, 1¾ kegs	3.25	5.69		
Spikes, 9 inch, 2¼ kegs	3.12½	7.03		
Spikes, 9 by ⅜ inch, 1½ kegs	5.70	8.55	0.005 keg	.09
Total		605.79		2.77
Construction, 1,351 hours	.16	*216.16	6.21 hours	.99
Sailor work, 310 hours	.16	*49.60	1.42 hours	.23
Total		265.76		1.22
Grand total		871.55		3.99

*Including subsistence.

Estimate of actual cost of material, labor, and subsistence, etc.—Continued.

DIKE No. 2.—Continued.

[Revetment No. 2, 23,000 square feet.]

Item.	Cost per unit.	Cost.	Per 100 square or cubic feet.	
			Item.	Cost.
Brush, 325 cords	1.09	354.25	1.413 cords ...	1.54
Poles, 45 cords	1.48	66.60	0.196 cord	.29
Stone, 649 tons	1.95	1,265.55	2.822 tons.....	5.50
Wire, 22 coils	3.37	74.14	0.096 coil	.32
Spikes, 6-inch, ½ keg	3.25	1.62	.....	.....
Spikes, 9-inch, 3 kegs	3.12½	9.37	.....	.....
Spikes, 9 by ⅝ inch, ½ keg	5.70	2.85	0.017 keg	.06
Total	.....	1,774.38	.....	7.71
Grading, 5,000 hours	.16	*800.00	21.74 hours ...	3.48
Construction, 3,584 hours	.16	*593.44	15.58 hours ...	2.58
Total	.....	1,393.44	.....	6.06
Grand total	.....	3,167.82	.....	13.77

* Including subsistence.

[Spur No. 2, 3,000 cubic feet.]

Brush, 7 cords	1.09	7.63	0.233 cord.....	.25
Poles, 10 cords	1.48	14.80	0.333 cord.....	.49
Stone, 16 tons	1.95	31.20	0.533 ton.....	1.04
Wire, 2 coils	3.37	6.74	0.066 coil.	.22
Total	.....	60.37	.....	2.00
Construction, 202 hours	0.16	*32.32	6.073 hours ...	1.08
Grand total	.....	92.69	.....	3.08
Cost of entire dike No. 2	.....	9,661.28	.....	.....

* Including subsistence.

Care of fleet, pumping, etc., 5,030 hours, at 17 cents	*$855.10
Coaling *Vidalia* and pile-driver, 979 hours, at 17 cents	*166.43
Digging dead men, pulling drift, etc., 469 hours, at 17 cents	*79.73
Helper for carpenter, 304 hours, at 17 cents	*51.68
Total	1,152.94

* Including subsistence.

Cost of subsistence.

1889.	Ration raw.	Ration served.	Labor secured.
	Cents.	*Cents.*	*Cents.*
September	29¾	40¼	43⅓
October	29¼	34¼	36⅓
November	30¾	44¼	46½

FINANCIAL STATEMENT.

Greenville Reach.

May 31, 1889. Balance allotment act of August 11, 1888		$33,595.64
Expended to May 31, 1890, for—		
Labor on construction	$8,078.22	
Material for construction	10,178.77	
Subsistence	3,806.97	
Cost plant, repairs, and outfit	870.28	
Care of public property	4,463.60	
Towage and steamer expenses	2,002.70	
Administration and office expenses	128.31	
Surveys	582.06	
Miscellaneous	2.25	
		30,113.16
Balance in hand June 30, 1890		3,482.48
Less liabilities		586.33
Available balance June 30, 1890		2,896.15
Amount that can be profitably expended in fiscal year ending June 30, 1892		350,000.00

LAKE BOLIVAR FRONT.

A special allotment for this work was made by the river and harbor act of August 11, 1888. The object of the improvement is to stop the caving of the bank in front of the large and costly levee across the end of Lake Bolivar, which was being threatened by the rapid encroachment of the river. During the latter part of 1888 and the beginning of 1889, a part of the bank immediately in front of this large levee was revetted.

The details of this work are set forth in the annual report of the Chief of Engineers for 1889, pages 2704 *et seq.*

This work, so far as carried out, was perfectly successful in stopping caving. Below the work, the bank is still caving rapidly, and the revetment will probably have to be extended down-stream for a considerable distance.

The operations at Lake Bolivar front during the year ending May 31, 1890, consisted simply in repairing some of the revetment constructed during the previous year. The details of the work are fully set forth in the following report of Mr. H. St. L. Coppée, assistant engineer, who was in local charge of the repair work.

The present condition of the work is unknown, as the river is still too high to permit an examination to be made.

REPORT OF MR. H. ST. L. COPPÉE, ASSISTANT ENGINEER, ON WORK DONE DURING THE YEAR ENDING MAY 31, 1890.

October 24 I made an examination of the bank of the river in the vicinity of Bolivar Landing, Miss., and, but for the need of a little rock, found pretty much the entire revetted bank in good shape, except at a point where the Bolivar Warehouse stood; also at the lower end of the work of 1888. It may be well to state here that in that year 4,400 lineal feet of mattress-work and 4,250 feet of revetment was built along this front to keep the river from caving into the large levee across Lake Bolivar, thus exposing the back country to excessive overflow at high water and seriously deranging the regimen of the river in that vicinity. (See report of Chief of Engineers, 1889, page 2704.)

At the warehouse my examination showed that the old broken-up revetment would have to be taken off the bank and the bank graded. Near the lower end of the work I found the revetment again badly broken, and reported that little could be done there with the small means allowed, but put new revetment on the bank in places over the old. The mattress-work seemed to be intact all along the revetted bank to the very end, where it was considerably broken up and where it was proposed to do the patch-work by sinking a mattress.

We were troubled at this point again by inability to obtain or keep reliable labor; men would come to the locality, but after working four or five days would leave in large numbers, placing operations practically at a standstill. November 1 work commenced here and was carried on continuously till November 26, with the same plant and force of foremen, etc., used at Greenville. The rock used in construction was obtained from the piles of rock stored at Bolivar in 1888.

November the 9th, I was instructed to send my steam-boat, the *Vidalia*, to Ashton, where more extensive work was in operation, and where, unfortunately, their tow-boats were all broken down, thus practically stopping the work of over 500 men. At the time the river was rising, my mooring barges and mat-boats were in place, and a very small part of the lower mat, shown in accompanying map, was built. I had hoped to construct and sink the mat before the river reached such a height as would make the work dangerous and difficult, but owing to the absence of the steam-boat, which was detained about a week, the conditions were very unfavorable when the mattress was being completed.

The mattress was finished and ready to be sunk November 21. It was 244 feet long by 240 feet wide. There was 500 feet of drift piled in front of it, 350 feet wide, and probably 20 feet deep. This latter proved too great a strain during the process of sinking; every line and cable (17 in all) broke, and the mat drifted down the river retaining its normal shape, but we were unable to fasten it to the bank at any point.

As the portion of the bank this mattress was to occupy was to some extent protected, and as it was supposed to have been built at low water and extend further out into the river than the old work, and also on account of the fact that the water was rising above, it was deemed expedient to give up all idea of a mattress at that point that season. The other work, consisting of a foot-mat and revetment, is shown in accompanying sketch. The foot-mat is 255 feet long by 65 feet wide, the revetment 270 feet long by 42 feet wide. The grading was done in the same manner as that at Greenville.

In order to thoroughly protect the lower end of this reach, and make the work permanent, at least half a mile of the strongest kind of revetment should be placed on the bank from the warehouse down the river, and a thorough system of drainage established, if possible, to do anything with the sloughing caused by seep water from adjacent holes and lakes. The approximate cost of putting this work in good condition and extending it as stated, say 2,000 feet down the river, would be $100,000. This would include adding considerable rock to the revetment completed in 1888.

The material, with the exception of rock, was obtained from the same source and at the same place as for the Greenville Reach.

Cost of material, labor, and subsistence in building mat and revetment at Bolivar, 1889.

[Deep-water mattress, 235 by 244 feet wide, 57,340 square feet.*]

Items.	Cost per unit.	Total cost.	Per 100 square feet.	
			Item.	Cost.
Brush, 352 cords	$1.27½	$448.80	.614 cord	$0.78
Poles, 83 cords	1.47½	122.42	.145 cord	.21
Stone, 225 yards	2.30	517.50	.393 yard	.90
Wire, 34 coils	3.37	114.58	.059 coil	.20
Cable, 6½ coils	42.27	274.75	.011 coil	.47
Spikes (6-inch), 2½ kegs	3.25	8.12		
Spikes (9-inch), 2½ kegs	3.12½	7.81		
Spikes (9⅜-inch), 3¾ kegs	5.70	18.52	.014 keg	.06
Staples, ¾ keg	5.00	3.75	.001 keg	.01
		1,516.25		2.63
Construction, 4,292 hours	.17	†729.64	7.49 hours	1.27
Sailor work, 977 hours	.17	†166.09	1.71 hours	.29
Total		895.73		
Grand total		2,411.98		

Cost of material, labor, and subsistence in building mat, etc.—Continued.

[Foot mat, 255 by 65 feet wide, and revetment 270 by 42 feet wide, 16,575 + 11,340 = 27,915 square feet.]

Items.	Cost per unit.	Total cost.	Per 100 square feet.	
			Item.	Cost.
Brush, 178 cords	$1.27½	$226.95	.638 cord	$0.81
Poles, 36 cords	1.47½	53.10	.129 cord	.19
Stone, 561 yards‡	2.30	1,290.30	2.011 yards	4.62
Wire, 20 coils	3.37	67.40	.072 coil	.24
Cable, 2⅛ coils	42.27	91.58	.008 coil	.34
Spikes, 1¾ kegs	3.25	5.69		
Spikes, 1 keg	3.12½	3.12		
Spikes, 1¾ kegs	5.70	9.97	.016 keg	.07
Staples, ¼ keg	5.00	1.25	.001 keg	
		1,749.36		6.27
Construction, 2,794 hours	.17	†474.98	10.01 hours	1.70
Sailor work, 194 hours	.17	†32.98	.69 hour	.16
Clearing and grading, 4,180 hours	.17	†710.60	4.98 hours	2.55
Total		1,218.56		4.41
Grand total		2,967.92		10.68

* This mat was lost in sinking, which accounts for small amount of stone used.
† Includes subsistence.
‡ About 75 yards of this stone used on old revetment.

Care of fleet during whole work, 1,926 hours, at 17 cents	$327.42
Loading 1,310 yards stone on barges, 4,024 hours, at 17 cents	684.08
Moving drift during work, 480 hours, at 17 cents	81.60
Coaling steamer during work, 273 hours, at 17 cents	46.41
Grinding axes, etc., during work, 166 hours, at 17 cents	28.22
	1,167.73

Cost of subsistence.

Ration, raw	$0.40
Ration, served	.46
Ration served in proportion to labor secured	.54

FINANCIAL STATEMENT.

May 31, 1890, balance allotment, act of August 11, 1888		$47,511.49
Expended to May 31, 1890	$12,221.77	
Transferred to surveys, examinations, and inspections, third district	4,000.00	
Transferred to surveys, examinations, and inspections, fourth district	3,000.00	
Transferred to protection of levees, fourth district	3,000.00	
Transferred to protection of levees, third district	5,000.00	
		27,221.77
May 31, 1890, available balance		20,289.72
Of which in hand	289.72	
In Treasury	20,000.00	
		20,289.72

There are no liabilities.

Expenditures apportioned for—	
Labor on construction	$3,513.41
Material for construction	3,227.15
Subsistence	1,978.43
Cost plant, repairs, and outfit	355.21
Care of public property	778.09
Towage and steamer expenses	1,779.17
Administration and office expenses	96.00
Surveys	398.91
Medicines and medical attendance	85.00
Miscellaneous	10.40
Total	12,221.77
Amount that can be profitably expended during fiscal year ending June 30, 1892	100,000.00

HIGH-WATER PROTECTION OF LEVEES AND THE FLOOD OF 1890.

The high stage of the river in January seemed to indicate that an annual flood of considerable magnitude would obtain. A natural general curiosity was excited in anticipating the effect of the new Arkansas levees. For the first time in a number of years a continuous line of levees existed on both sides of the river, and, if as was expected, this should prove a flood year, it was of the greatest importance that these levees should be held, in order that their effect in scouring out the bed of the river might be determined. There seemed to be a general determination to hold the levees, if possible, on the part of the Mississippi River Commission, the different State levee boards, and the people generally.

The funds in my hands at this time for levee protection work amounted to $18,701.50 only. Since the State levee boards of Mississippi and Louisiana were pushing levee work vigorously, and seemed to have plenty of funds on hand, while nothing whatever was being done in Arkansas, I thought it best to confine operations to the Arkansas line alone. Accordingly, Assistant Engineer Tollinger, who had been engaged for several years on the Arkansas levees, and who was more familiar with their then condition than any one else, was sent to make a careful examination of the whole line; to repair and strengthen the weakest parts where danger actually existed, so far as the funds would permit; and to arrange for such thorough inspection of the line as might be needed during high water.

A force of hired teams was put to work raising the large and important Whisky Chute and Grand Lake levees which had settled, the former to 5 feet and the latter to 3½ feet above the high water of 1888.

Early in March the flood had attained alarming proportions, and the high stages of the Ohio River and its tributaries, from which the flood mainly proceeded, together with the persistent and long-continued high water in White River, seemed to threaten a flood that would overwhelm the levees and spread general disaster if the most heroic efforts were not made to strengthen and raise the levees. Alive to the danger, General Comstock, president of the Commission, took prompt steps to have the necessary funds provided for protection work, and accordingly $25,000 were transferred to the protection fund on March 11, $32,000 on March 18, and $27,250 on March 21.

Before these transfers were made the people of Arkansas, upon the persistent solicitations of United States Assistant Engineer Tollinger, and especially after they realized the danger threatening them, contributed liberally and worked manfully in holding their line.

Hard and expensive fights were being made by the board of Mississippi levee commissioners, and especially by the board of the fifth Louisiana levee district, in holding their respective lines.

Had it not been for the very energetic and heroic work of the several State levee organizations, supplemented by the timely and liberal assistance rendered by the General Government, a very considerable portion of the levee line would have been breached, and the overflow would have been much more general and disastrous than it proved. I do not think it an exaggeration to say that 50 miles of levee in the third district would have been overtopped by the flood had not the levees been hurriedly raised by topping, or with sacks filled with earth. In some instances the line was held by a sack wall, where the water was fully 2 feet higher than the top of the levee.

As soon as the transfer of funds for levee protection purposes was made, it was decided, in the absence of instructions on the matter, that assistance should be given wherever needed within the limits of the district, whether on one side of the river or the

other, and without considering whether the levees had been built by the United States, by the State levee boards, or by private corporations and individuals. The presidents of the several State levee boards and their engineers were seen at once, and told that any assistance they might need would be cheerfully and promptly furnished.

The work in Arkansas, as had been done before, was continued under direct Government supervision.

It was suggested by me that, in continuing the work in Mississippi and Louisiana, the State levee organizations should pay for all labor, while the Government should furnish all material, such as sacks, bagging, lumber, etc., needed to protect the levees.

This arrangement was agreed to, and for a time was carried out, but towards the end of March the funds of the Louisiana board were so nearly exhausted that it became necessary for the Government to assume complete charge of all protection work in that State, which was accordingly done, Mr. Henry Goodrich, assistant engineer, being placed in immediate charge.

No assistance in labor was asked for or furnished in Mississippi except at the crevasses, where the work of protecting ends of broken levees was paid for by the United States. By agreement this work was done under the immediate supervision of the chief engineer of the Board of Mississippi Levee Commissioners, Maj. William Starling.

Detailed accounts of the work done in the third district since January in protecting the levees from flood; in gauging the discharge of the river at Wilson's Point, La., and at Arkansas City; in gauging the discharge at the several crevasses; in establishing high-water marks; in determining the extent of country overflowed; in attempting to close the Offutt Crevasse; in protecting the ends of broken levees at other crevasses, and in removing people and stock from flooded districts are given in the following reports of assistants.

All the data collected respecting the flood is given in these reports, or in the tables, statements, and drawings following.

During my absence from the river, in office work at Memphis, the general supervision of the work of levee protection in the third district was intrusted to Mr. Arthur Hider, assistant engineer. His administration of the work was at all times characterized by energy, intelligence, loyalty, and good judgment. He was ably assisted by Mr. E. C. Tollinger, assistant engineer in charge of the Arkansas levees, and by Mr. Henry Goodrich, assistant engineer in charge of the Louisiana levees, and to all these gentlemen the greatest credit is due.

During the continuance of the flood I made a number of trips on the river from Memphis to Vicksburg. I could not help noticing that the trade along the river was almost completely paralyzed during the overflow. The conviction was forced upon my mind that an improvement of the river for high-water navigation was quite as important and necessary and of vastly more general benefit than an improvement for low-water navigation alone. By a high-water improvement I mean such control of the flood waters as shall surely protect the country from overflow and allow business to be carried on along the banks of the river during the whole season of high water.

This can not be done without the aid of levees, and therefore I regard it quite as much the duty of the General Government to build levees as it is to revet banks or build dikes. If levees are not built to restrain the floods and prevent overflow by the Government, by the States, or by individuals, it may well be doubted if the benefits to be derived from a low-water improvement of the river in the manner now being carried out by the Mississippi River Commission will justify the cost. On the other hand, if the Government shall aid in building such levees as will give security against overflow, there will be a great development of the whole Delta country, a large part of which is now virgin forest, and the commerce and trade of the river will be wonderfully increased.

This hope alone can, in my mind, justify the expenditure of the vast sums of money that will be needed to in any way effectually and surely improve the navigation of the river.

An effort has been made to collect and furnish as full data as possible respecting the flood; but no study or discussion of it has been attempted by me, both for lack of time and because, doubtless, a full discussion and report on the flood will be made by the Commission, from the information furnished from this and other districts, supplemented by data collected from other sources.

REPORT OF MR. ARTHUR HIDER, ASSISTANT ENGINEER, ON THE HIGH-WATER PROTECTION OF LEVEES AND THE FLOOD OF 1890.

The steady rise of the river in February, which, at the beginning of the month was only 2 feet below the highest recorded water at Greenville, caused apprehension in regard to the safety of the Arkansas levees. A thorough inspection of the line was

made, and work done on some of the weakest places. As only a small balance was at that time available, but little work could be done, and this only where the needs were most urgent. The river rose steadily, until, near the end of the month, it had reached the highest previously recorded water at Greenville, and the danger of a flood became imminent.

The flood of 1890, while not reaching the extreme height of previous floods at Cairo, has at several points in the third division exceeded the heights of any previously recorded high water.

The fact of a continuous line of levees being in existence on both sides of the river for the first time for a number of years, will cause this flood to be classed in the list of the great floods, so far as this particular section is concerned, as the height of the water between the levees, by reason of its being confined, exceeded that of previous years, and the crevasses that occurred on both sides of the river when the flood was nearly at its maximum, caused a wide-spread and disastrous overflow.

This flood exceeded in height the floods of 1882, 1884, and 1886 by 2.3 feet at Arkansas City, 1.7 feet at Greenville, 3.1 feet at Wilson's Point, and 0.1 foot at Vicksburg.

The limits of the overflow caused by crevasses have been obtained from a reconnaissance made of the localities inundated, and are approximately correct. Parties were sent out on each side of the river to trace the line of backwater.

The plantations everywhere, except in a few places located on the highest ridges, were entirely submerged, and while a less extent of territory has been overflowed than in 1882, the damage to stock and property has been very great, and the lateness of the season will prevent, in many cases, the possibility of raising a crop after the water subsides. This will render the actual damage inflicted on the community in the overflowed district fully as great as that of any previous flood.

The limits of the land submerged are given below:

Right bank.—From the mouth of the Arkansas River the backwater came close up to the levees as far down as Sunnyside, from there to Bedford at the lower end of the district, there was a narrow strip of land (except in the vicinity of the Raleigh Crevasse) close to the river bank, from 1 to 8 miles wide, which was not submerged.

The western limits of the overflow extended up the Arkansas River to Millwood, crossing the Little Rock, Mississippi River and Texas Railroad about a mile below Varney, and skirting along the upper side of Wells, Choctaw, and Amos bayous; it then crossed Amos Bayou and ran in a southerly direction to Tillar, 18 miles west of Arkansas City, thence following the railroad embankment to within 3 miles of Trippe Station, thence south along the high ground between Bayou Bartholomew and Bœuf River to the Ouachita River, about 15 miles below Monroe. The high ground between Bayou Macon and Bœuf River, from as high up as Lakeport, was not overflowed.

This strip has an average width of 5 miles.

The counties overflowed in Arkansas were the northeast portion of Lincoln, the greater part of Desha, nearly all Chicot, and a small part at the southeast corner of Ashley County.

In Louisiana, more than one-half of East and West Carroll, the eastern part of Moorhouse and Ouachita, and portions of Richland, Franklin, and Madison Parishes were submerged. The country overflowed within the above limits contains 3,050 square miles.

Within these boundary lines, 560 square miles of land was high ground above overflow, or about 15½ per cent.

Left bank.—The upper limit of the back water is in the vicinity of the town of Bolivar, and from there follows in a southeasterly direction to the Yazoo River.

Nearly all the ground west of this line was inundated to a depth of from 1 to 6 feet; this area embraces the southwest portion of Bolivar County, nearly all of Washington County west of the Sunflower River, a small portion of Sunflower County, all of Isaquena County, and, with the exception of a strip of land along the Louisville, New Orleans and Texas Railroad, all of Sharkey County, that part of Warren County which lies west of the Yazoo River, as well as a large portion of Yazoo County itself, which is west of the Yazoo River.

The above territory embraces an area of about 1,978 square miles, and, except about 89 square miles, or about 4.4 per cent. on the highest ridges, was completely submerged.

A map showing the limits of the overflow within the district, plate 2, is submitted herewith.

During the months of March and April, the river remained at flood height.

Such portions of the working plant as could be used to advantage were employed in transporting material to various points in the district, where most needed for strengthening and raising the levees, giving shelter to overflowed people, and moving people and stock to places of safety.

Forces were put on at critical points, and worked in connection with other forces employed by the local levee boards.

The United States steamers *Emma Etheridge*, *Osceola*, and *Vidalia* were put in service with double crews, the *Osceola* being engaged after the 15th of March almost entirely on the levees in the fifth Louisiana levee district, the *Vidalia* at Arkansas City, and the *Etheridge* in general work along the entire line. The *Vidalia* broke her shaft on March 20, and the *R. A. Speed* was chartered in her place. The *H. M. Graham* was obtained from the second district. Both these boats were constantly employed during the emergency of the flood.

Inspectors were placed all along the Arkansas front, as it was considered that, on account of the low grade and small section of many of these levees, more work would be needed here than elsewhere, while at the same time the local organizations in this State were not nearly so strong as those in Louisiana or Mississippi.

Assistance in the way of material, sacks, lumber, and the use of plant, to aid in raising and strengthening levees, was given to the levee authorities on both sides of the river whenever called for, and as promptly as possible.

In the beginning, the forces of laborers were paid by the local levee boards and the work was directed by the inspectors. When the situation became more critical and the funds of the local boards for protection purposes had been nearly exhausted, these forces on both sides of the river were worked and paid entirely by the United States.

A quarter-boat, to afford temporary shelter to overflowed negroes, was left at Chicot, Ark., and also one at Skipwith's, Miss., after the break in the levee at that point; these were of great service to the people who were overflowed.

Prompt assistance was rendered by the United States steam-boats in removing people and stock to places of safety.

Five barges of stock were towed from the vicinity of Mound and Huntington crevasses to Arkansas Post, and some three hundred people who had been overflowed were taken to places of safety, either at Arkansas City or at Arkansas Post.

The following is a list of the boats employed in levee protection and in giving assistance to people suffering from the overflow: 6 steam-boats, 4 quarter-boats, 7 pile-drivers, 12 barges, 1 mat boat, besides 35 skiffs and small flats.

All the employés have shown a commendable interest in the special work intrusted to their charge and have rendered valuable and efficient service both to the work and also to the general community.

CREVASSES.

The first crevasse in the levees occurred March 9, at Sappington, 9 miles above Arkansas City, and was caused from the water forcing itself through the levee near the base.

From the best information obtainable, the crevasses at Catfish Point, Easton or Mound, Huntington, Offutt's, and Skipwith's, in Mississippi, and that at Raleigh, La., happened in a similar manner.

The long continued pressure of water against the levees caused them to become thoroughly saturated, and the porous material which constitutes, in a great many instances, the foundation of these levees, aided by the location of borrow pits and side ditches near the base, permitted the percolation of water through the levees at and below the natural surface of the ground, thus allowing the hydrostatic pressure caused by the head of water in front to be transmitted to the land side beyond the base, causing an upheaval of the ground and permitting a flow of water through or under the levee, thus causing a break.

The crevasses in Opossum Fork Levee, between Boggy and Amos Bayous, Furguson's, 2 miles above Chicot, near Chicot, 2 miles above Arkansas City, and at Luna, Ark., were from settlement of the levee, due to saturation and imperfect foundations, as shown by longitudinal cracks, which appeared first in the crown of the levee, followed by a sloughing off of part of the back slope.

This sloughing continued until the section of levee itself had become too weak to resist the pressure of water against the front, and the levee broke.

The breaks in the levees around Point Chicot occurred on March 5 and 6, when the river was 1.8 feet below its highest point, and were caused by insufficient height.

The break in the Leeland Loop Levee, below Columbia, took place during a storm, and was from insufficient section, as well as height.

The Opossum Fork Levee, where it is crossed by Boggy Bayou, was purposely cut by parties living above under the impression that it would afford relief to them from the back-water.

The remedy to prevent a recurrence of these disasters in the future suggests itself:

(1) A greater height of embankment.

(2) A larger section.

(3) More care in selection of material and in details of construction of the foundation.

(4) The additions of a berm on the land side, where the material is porous, to give the necessary weight and stability to counteract the water pressure from the river side.

The Offutt's crevasse, which occurred on March 18, was the first break in the Mississippi levees.

As instructed by you, on March 21 a force was organized, material procured, four pile-drivers put in service, and work begun on the 23d in driving piles to close the crevasse. The plan was to drive a double row of piles across the break about 5 feet apart, the distance between the rows of piles to be one and one half times the depth of water, sheet piling 2 by 6 inches to be driven in front.

It was intended to use brush to prevent scour in front, and, behind the sheet piling between the rows of piles, to fill up solidly with sacks of earth.

The depth of water was from 7 to 14 feet. The work was well under way, with the promise of a successful termination, when, on the night of the 27th, the crevasses at Huntington and Mound occurred.

The back water rose so rapidly from these breaks that it was evident that the closure of this crevasse would do little good toward preventing an overflow. The work was abandoned on the 29th and the plant moved elsewhere, after some 40 piles had been driven in place.

To prevent the crevasses from widening various plans were tried at different localities.

(1) Revetting the ends of the levees by stringing sacks filled with earth around the end of the broken levee, thus protecting the end from further scour.

(2) Making and sinking a pliable willow mattress along the outside, above the broken end, which, as the levee caved back, was wrapped around the exposed end by the action of the current.

(3) By building out a dike of brush and sacks or piles and brush above the broken end to deflect the rapid current flowing along the base of the levee and direct it through the gap more nearly perpendicular, and thus relieve the broken ends from the scouring action of the water.

The first plan, that of revetting with sacks of earth, failed in every instance in which it was tried, the end of the levee being constantly undermined while the work was being done, and notwithstanding constant renewals in not a single instance was any satisfactory or permanent result accomplished.

For a high levee, where the depth of the water flowing through is over 4 or 5 feet, this plan is not recommended, as it was given a fair trial in a number of instances.

The method of protecting the ends with a pliable willow mattress was tried at the Raleigh break, and, after repeated failures of the sack revetment method, at the upper end of the Skipwith break also. This plan was successful at the upper end of the Raleigh break, but required constant work and additions from day to day, as the scour along the base of the levee kept undermining the mat. At the lower end of the crevasse the mattress failed to hold the end; after the caving had extended down to the mat the undermining of the levee continued, and the result was that a great deal of extra work became necessary to prevent the crevasse widening.

At Skipwith's, after the mat had been sunk in place, from the experience at Raleigh it was thought advisable to supplement it by building a dike, jutting out from the levee, to stop the current flowing along the base.

Wherever dikes were used to deflect the water from the base of the levee the results were quite satisfactory, and after our unfavorable experience with the sack revetment (the plan heretofore usually followed) for protecting the ends of broken levees dikes were used.

These dikes were constructed in various ways, depending upon the locality, the difficulty of getting barges or pile-drivers to the crevasses, the kind of material available, or the particular locality suggesting difference in the details.

The object sought to be obtained was to stop the scour caused by the rapid current flowing along the base of the levee, and thus preventing the undermining and caving away of the ends.

A description, giving the details of the different constructions used, is given below.

Luna Crevasse.—In front of this crevasse was a growth of heavy timber which precluded the possibility of getting a pile-driver to the break. A number of large trees, close to and in front of the levee, were utilized in lieu of piles.

These were connected with wire cables, fastened around and leading from tree to tree; the cables were stretched at different heights above the ground, and against these cables brush was floated; this lodging against the cables and trees, formed a brush dike, deadening the current sufficiently to allow the building out of a dike made of sacks of earth immediately below the brush.

More brush was then added, and when finished there was constructed a solid dike

of sacks of earth, the front of which was protected with brush and small trees to prevent scour.

The dike was about 18 feet wide, and extended out from the levee about 70 feet, shielding about 100 feet of the levee below the dike, and directing the flow through the crevasse nearly at right angles to the levee, stopping the undermining and consequently further caving of the broken end of the levee. The same method was applied to the lower end. The result was entirely satisfactory, and no further work was needed.

Columbia Break.—This dike was made of a single row of piles driven from 15 to 20 feet in the ground, and spaced about 5 feet apart. The scarcity of brush in the vicinity and the lack of barges and towing facilities rendered some other plan advisable. Cypress plank 2 inches thick, and from 12 to 16 feet long, were spiked together, forming shutters about 10 by 16 feet. These were placed against the front of the row of piles, shutting off the flow sufficiently to allow the building of a solid dike of sacks of earth immediately below. Afterwards it was found necessary to float brush against the upper side to prevent scour along the front, and especially at the outer end of the piles.

The lower end of this crevasse was treated in the same manner; result, complete success.

Skipwith's Crevasse.—The lower end of this crevasse was secured by a dike built of sheet piles, driven by hand, re-enforced with sacks of earth. To protect the upper end a revetment of sacks around the broken end was repeatedly tried, but was as often undermined and carried away. A dike built out from the levee, composed of brush and filled sacks was then attempted; the first was scoured out and a second one constructed, but it was found impossible to carry the dike so built far enough out from the base of the levee on account of the depth of water, 27 feet, caused by scour through the borrow pits located close to the base of the levee, to be of any service in deflecting the current.

In a few days this second dike was undermined and carried away. Recourse was then had to a mattress. This was built of small-sized willows on a mattress barge about 50 feet above the broken end of the levee. Instead of weaving poles, and so as to render the mat more pliable, $\frac{3}{8}$ inch cotton rope was used to bind the willows together; sacks of earth in tiers were fastened on the mat to sink it, and the mat launched into the water, the current sinking it and holding it against the slope of the levee. As the levee caved back the mat swung around against the broken end, and afforded a partial protection against scour.

As the current along the slope of the levee was very swift, and the experiences elsewhere of mattresses not being entirely satisfactory, it was deemed advisable, to render the work entirely safe, to supplement it with a dike. A dike of piles and board shutters, similar to that built below Columbia, was put in, and no further caving took place. At the Sappington Crevasse the dikes were constructed of sacks of earth and rock and were successful in holding the ends of the broken levee.

Furguson Crevasse.—The north end was protected by a dike of sacks filled with earth, the south end by a dike of piles and a screen mat in front of the piles to deaden the current.

Brook's Field Crevasse—Opossum Fork Levee.—North end protected with dikes of sacks, south end revetted three times and each time the revetment was washed out.

Crevasse between Arkansas City and Chicot.—North end protected with dike of timber, filled in with sacks extending out from the levee about 40 feet. Three dikes of sacks built at the lower end washed away.

Chicot Crevasse.—Ends protected with dike of piles, sacks of earth, and brush.

Crevasse at Catfish Point.—Ends protected by dike of piles, sacks of earth, and brush.

Crevasse at Mound.—Ends protected by dikes of piles, sacks of earth, and brush.

Opossum Fork Levee at Boggy Bayou.—Ends protected by felling trees and building dike of sacks filled with earth.

At Huntington.—The breaks on the lower side of Catfish Point and the small break above Greenville, nothing was done to protect the ends, as, except on the lower side of Catfish Point, where the breaks were due to the backwater from the Catfish crevasse flowing across the point and overtopping the levee, little caving back of the ends took place after the breaks happened.

At Offutt's.—The sack revetment was given a number of trials and in each case was undermined and carried away.

At Raleigh Crevasse.—The ends were protected by mattresses with only partial success, as much additional work was required. From the experience of this season's work it has been demonstrated that the method of revetting the ends of broken levees with sacks of earth is not applicable where the current is swift and the water flowing through the crevasse deep.

Of the other two plans tried, that of revetting the broken ends with a willow mattress, or building dikes to deflect and direct the current through the crevasse, the mattress was found to be the most expensive and required constant care and contin-

ual work to keep up, while the dike method. in every instance where tried, proved a success.

The heights of the old levees, contiguous to the crevasses with an approximate estimate of the cost of closing the gaps to the new grade, is given in the following statement:

For levee protection purposes a large amount of material was used. The principal items are given below.

There remains on hand about 71,000 sacks, which were purchased but not used.

Sacks expended		440,000
Lumber	feet..	470,046
Twine	pounds..	2,520
Bagging	yards..	35,700

The labor cost of the forces was:

Month.	Pay-roll.	Subsistence.	Total.
February, 1890	$1,390.37	$77.44	$1,467.81
March, 1890	24,460.61	2,614.13	27,074,74
April, 1890	17,267.04	1.312.40	18,579.44
Total	43,118.02	4,003.97	47,121.99

Approximate cost of closing crevasses, third district, 1890.

Location of levees.	Extreme height.	Average height.	Old grade.	New grade.	Length to close break.	Cubic yards.	Approximate cost at 20 cents per cubic yard.
	Feet.	*Feet.*	*Feet.*	*Feet.*			
Catfish Point, Miss	16.0	10.6	3.2 above 1882	3.0 above old	7,515	267,940	$53,588
Catfish Point, (lower side, small breaks)	14.0	10.2	3.0 above 1882	3.8 above 1890	3,528	90,300	18,060
Easton's or Mound, Miss	14.0	12.0	3.0 above 1882	3.8 above old	5,000	251,570	50,314
Huntington, Miss	14.0	9.9	5.0 above 1888	3.8 above old	3,000	85,570	27,114
Offutt's	13.0	10.1	3.0 above 1888	3.0 above old	3,000	74,690	14,938
Small break above Greenville	.....	.....	.....	3.0 above 1890	300	5,960	1,192
Skipwith's, Miss	16.3	8.4	5.0 above 1888	3.6 above old	4,500	145,730	29,146
Small break Point Chicot, Ark	6.0	4.0	0.0 above 1888	3.0 above old	4,000	37,920	7,584
Sappington, Ark	10.0	8.0	5.0 above 1888	3.0 above old	650	19,136	3,827
One mile above Luna, Ark	18.0	12.0	3.0 above 1888	5.0 above old	2,000	58,880	11,776
Two miles above Arkansas City, Ark	8.0	7.0	4.0 above 1888	3.0 above old	400	11,776	2,355
Chicot, Ark	10.0	8.0	5.0 above 1888	3.0 above old	250	7,365	1,473
Ferguson's (2 miles above Chicot)	12.0	10.0	5.0 above 1888	3.0 above old	350	10,309	2,061
Boggy Bayou (opposite Fork, Ark	57.0	25.0	5.0 above 1888	3.0 above old	300	30,000	6,000
One mile below Columbia, Ark	10.0	9.0	3.0 above 1888	6.0 above old	650	19,136	3,827
Brooksfield (opposite Fork), Ark	12.0	8.0	5.0 above 1888	3.0 above old	700	20,608	4,121
Raleigh, La	12.0	10.0	5.0 above 1888	3.0 above old	6,000	176,640	35,328
Total	.....	.....	.....	.....	.....	1,313,530	262,704

NOTE.—Quantities for Mississippi obtained from chief of engineer Levee Board, and provide for new levees on permanent location as proposed to be built. For Arkansas and Louisiana the estimate is made for loops or for closing the gaps on the old line.

DISCHARGE.

The maximum river discharge was measured at Wilson's Point, La., on July 3, 4, and 5, 1889, by Assistant Engineer Tollinger.

In 1890, from January 24 to May 7, a party was engaged at Wilson's Point, La., measuring the river discharge, under the direction of F. P. Spalding, surveyor, and

also the Skipwith's crevasse, after it took place; sixty-eight complete river discharges and ten of the Skipwith crevasse were obtained.

At Arkansas City another gauging party was stationed during the time of highest water under the direction of Assistant Engineer J. J. Hoopes. Fourteen complete river discharges were obtained between March 14 and April 15 and a number of measurements of the different crevasses.

The water flowing into Lake Chicot through the Point Chicot breaks and Columbia and Luna crevasses was measured by Inspector A. F. Kilpatrick. The crevasse at Raleigh was measured on April 12 by Assistant Engineer Goodrich.

The results of these measurements are given in the reports of the chiefs of parties submitted herewith.

The observed discharge, gauge, mean velocity curves, and a discharge curve found by adding the crevasse measurement to the observed discharge, to show the volume that would have passed both Arkansas City and Wilson's Point had the levees remained intact.

Plates 3 and 4 are submitted as part of this report.

ARKANSAS CITY DISCHARGE.

The measurements of the flow passing between Arkansas City and the higher ground on the west at station Trippe, on the Little Rock, Mississippi River and Texas Railroad, was obtained as a check on the crevasse measurements on the right bank, which are all over, and within a few miles of the discharge section at Arkansas City.

By comparison with the crevasse measurements, it appears that part of the river discharge from the Arkansas River, when at its flood, flows around the end of Opossum Fork levee beyond Amos Bayou, and passes down through the low ground between Arkansas City and Trippe; the excess of this measured flow over what poured through the crevasses varied from 29,000 to 41,000 cubic feet.

A comparison of these measurements is given below:

[In thousands of cubic feet.]

Date.	Measurement crevasses R. B. above Arkansas City.	Measurement volume between Arkansas City and Trippe.	Difference.	Date.	Measurement crevasses R. B. above Arkansas City.	Measurement volume between Arkansas City and Trippe.	Difference.
Apr. 8	111	140	29	Apr. 12	110	145	35
9	120	146	26	13	106	143	37
10	117	148	31	14	104	142	48
11	114	146	32	15	99	140	41

The measurement of the crevasses on both sides of the river above the discharge section, increased by the additional water flowing between Arkansas City and Trippe, as shown above, has been added to the river discharge, to obtain the volume of water that would have passed Arkansas City, had the levees been of sufficient height to restrain the flood and no crevasses occurred.

An addition of 30,000 cubic feet has also been made to the observations prior to April 8, as the river was as high then as when the Arkansas City to Trippe gaugings were obtained, to account for the flow around the end of Opossum Fork levee.

Besides the river and crevasse discharges there have been plotted the hydrograph at Arkansas City, the difference in slope between Rosedale, 40 miles above, and Greenville, 40½ miles below, compared with Arkansas City (Plate 3).

The volume of water passing through the crevasses was obtained graphically, by plotting the observed discharges on the days they were measured, and reading off from the diagram the discharge for the particular day when the river discharge was taken.

The unusually large discharge on April 19 was evidently due to the crevasse at Offutt's, 7 miles below Arkansas City, which occurred at 4 p. m. on the 18th, and the Luna break, 28.5 miles below, that took place at 6 a. m. the same day; these breaks had the effect of causing a fall at Arkansas City while the river was at the same time rapidly rising above, causing a steepening of the slope immediately above, and also below the discharge section. This is shown by a sudden increase of slope of 0.4 feet between Arkansas City and Greenville, and 0.1 foot between Arkansas City and Rosedale.

The second large discharge, April 2, was due to the Huntington crevasse, on the left bank, ½ mile, and the Mound break, 3 miles above. Both of these occurred March

28, and on April 2 were discharging nearly their maximum, the sudden depletion from the main river causing an increased slope above the discharge section.

The falling off of the main river discharge April 2–11 was due to the large crevasse in the levee on the upper side of Catfish Point, 16 miles above. This break occurred April 4 and widened very rapidly.

The sudden depletion from the main channel at this point necessarily caused a flattening of the slope between here and the discharge section, which, combined with the discharge of the other crevasses, required an interval of some days for the former conditions of slope to re-adjust themselves.

The large discharge on April 13 was due to the rectification of conditions previously existing before the large crevasse on the upper side of Catfish Point took place, aided by the return flow on the lower side of Catfish Point Peninsula, 7 miles above Arkansas City, of over 110,000 cubic feet per second.

The result of these observations indicate that the maximum river discharge (including the Sappington break) that the levees at their present height, under same condition of slope, would be expected to pass at this point is about 1,300,000 cubic feet per second.

The maximum discharge found by including all crevasse measurements was 1,721,000 cubic feet, leaving 421,000 cubic feet, or one-third the entire river discharges to be provided for by additional heights of levees.

A comparison of the observed river discharges at Arkansas City and Wilson's Point is given below. The crevasses between the two discharge sections have been taken into account, and the observation at the upper station compared with that taken the day following at the lower station, when a discharge was measured on that day.

[In thousands of cubic feet per second.]

Date.	Wilson's Point.			Arkansas City.		
	River district.	Crevasses measurement.	Total.	Date.	River district.	Difference.
Mar. 15	1,221	7	1,228	Mar. 14	1,186	+ 42
20	1,166	40	1,206	19	1,418	—212
25	1,254	38	1,292	25	1,220	+ 72
28	1,216	54	1,270	26	1,228	+ 42
28	1,216	54	1,270	28	1,223	+ 47
31	1,199	99	1,298	30	1,250	+ 48
31	1,199	99	1,298	31	1,272	+ 26
Apr. 3	1,210	120	1,330	Apr. 2	1,339	— 9
5	1,144	133	1,277	4	1,221	+ 56
8	1,135	120	1,255	7	1,187	+ 68
10	1,118	119	1,237	9	1,220	+ 17
12	1,152	101	1,253	11	1,199	+ 54
14	1,094	92	1,186	13	1,335	—149
15	1,112	99	1,211	15	1,283	— 72

The increased discharge at Wilson's Point over that at Arkansas City is due to the Raleigh Crevasse, 34 miles below, which took place on March 15, and in a few days widened to 3,000 feet in width, and the Skipwith break, one-half mile above the discharge section, which occurred March 26; the effect of the former was to increase the slope below the discharge section, and of the latter, by the sudden depletion, temporarily to increase the slope above.

During the time covered by the Arkansas City observations the effects of the crevasses constantly occurring in the vicinity had also a tendency to decrease the river discharge at that station, except on the dates before referred to, as explained above.

WILSON'S POINT DISCHARGE.

The river discharge, and discharge through crevasses between Wilson's Point and Arkansas City, hydrograph at Wilson's Point, difference of slope between Wilson's Point and Greenville, 52½ miles above, and Duvall's, 38 miles below, compared with Wilson's Point, have been plotted. (Plate 4.)

The maximum river discharge found at Wilson's Point, 1,290,000 cubic feet per second, was on March 11, while the levees were practically intact, as no breaks had then occurred that would affect the discharge. On March 11 the river was 0.5 foot

below the highest stage reached four days afterwards, and 2.6 feet above any previously recorded high water. At the time the maximum river discharges were obtained the water was within a few inches of the tops of the levees, which in many places had been raised temporarily with filled sacks from 1 to 3 feet.

Gauge-readings of the permanent gauges and of temporary gauges kept by the levee board are given below.

HIGH-WATER MARKS.

A complete set of high-water marks have been made on trees or other permanent objects at distance of a mile or less apart, for the purpose of determining the high-water slope and as a reference for future heights of levees. These have been marked on both sides of the river through the entire length of the district.

In Louisiana the flood heights were marked under the direction of the fifth district levee board; in Mississippi, from the upper end of the district to Brunswick, by the Mississippi levee board; below Brunswick to Warrenton, and in Arkansas, the high-water marks were made by our own forces.

These are now being connected with permanent benches as rapidly as possible.

Profiles of the levees on both sides of the river, showing the relation between maximum flood heights and heights of levees, are submitted herewith. (Plates 5 and 6.)

The information as to the Mississippi levees, shown on the profile, was furnished by the Chief Engineer, who states:

"The grades of our levees in 1880 were taken from a line of levels run in 1882, previous to the repairs of the breaks of that year, with corrections for construction between 1880 and 1882, and the grades of 1890 from recent observations. Grades are referred to Memphis datum, and also to the high water of 1882, so far as known. The high-water marks of that year, however, were taken without much precision, and at very irregular, and sometimes long intervals, and are frequently involved in much obscurity. It will be remembered that our grades are only referred to 1882 in those parts of the upper end of our district where it was the highest water; in other parts, even of the upper end, 1886 was higher than 1882, and was hence adopted as the standard. Below Mound Landing, 1880 was taken as the standard, because it was confined between levees and without crevasses; 1888 differed from 1882 by very diverse figures, being at some portions of the confined reach equal to 1882, and at others below it."

The crevasses in 1890 all occurred in State levees, and in 1880 the line was complete; no crevasses took place that year.

The data for the Arkansas levees have been obtained from previous surveys made by the United States, and from surveys and examinations made the present season.

None of the crevasses occurred in levees built by the United States except the Columbia break; this was caused by the water overtopping the levee. The Opossum Fork Levee, where it crosses Boggy Bayou, was maliciously cut.

All the levees where breaks took place have been added to and strengthened by the United States at different times, but none of them were originally constructed by the Government.

The length of the line from the end of Opossum Fork Levee to the State line is 90 miles.

The gaps and breaks in this line in 1880 were from—

	Feet.
Amos Bayou to Arkansas City	17,200
Arkansas City to Linwood	20,840
Linwood to State line	56,610
	94,650

Or 17.9 miles.

In Louisiana the elevations of the high water of 1890, height of present levee, and natural surface at distance of about 5 miles apart, are shown on the profile.

This is all the reliable information at present available.

The Raleigh Crevasse occurred in a State levee which had been recently constructed

Gauge-readings of high water of 1890, *third district, improvement Mississippi River, from February* 1 *to May* 10, 1890.

Date.	Arkansas City, Ark.	Greenville, Miss.	Lake Providence, La.	Vicksburg, Miss.	Date.	Arkansas City, Ark.	Greenville, Miss.	Lake Providence, La.	Vicksburg, Miss.
	Feet.	*Feet.*	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*
Feb. 1	45.10	39.70	36.50	42.00	Mar. 23	48.80	43.17	40.20	47.00
2	45.30	39.95	36.82	42.40	24	48.90	43.23	40.22	46.90
3	45.40	40.20	37.15	42.80	25	49.00	43.29	40.25	46.90
4	45.50	40.40	37.40	43.00	26	49.20	43.36	40.10	46.90
5	45.60	40.60	37.57	43.30	27	49.30	43.41	40.00	46.80
6	45.80	40.80	37.80	43.60	28	49.00	43.25	39.90	46.70
7	46.00	41.10	38.22	43.90	29	48.80	42.95	39.75	46.55
8	46.10	41.20	38.30	44.20	30	48.60	42.85	39.60	46.50
9	46.10	41.25	38.43	44.40	31	48.50	42.83	39.60	46.40
10	46.10	41.20	38.52	44.60	Apr. 1	48.50	42.75	39.60	46.45
11	46.00	41.15	38.57	44.70	2	48.40	42.68	39.45	46.45
12	45.90	41.05	38.60	44.80	3	48.40	42.75	39.57	46.60
13	45.90	41.05	38.70	44 90	4	48.00	42.48	39.40	46.70
14	45.90	41.05	38.70	45.00	5	47.80	42.24	39.30	46.80
15	45.90	41.05	38.70	45.10	6	47.80	42.18	39.30	46.90
16	45.90	41.05	38.73	45.20	7	47.80	42.15	39.30	47.10
17	45.90	41.05	38.77	45.20	8	47.80	42.15	39.30	47.25
18	45.90	41.10	38.85	45.25	9	47.80	42.15	39.30	47.40
19	46.00	41.20	38.93	45.35	10	47.80	42.10	39.30	47.55
20	46.10	41.30	39.00	45.45	11	47.70	42.10	39.30	47.70
21	46.30	41.40	39.13	45.50	12	47.70	42.10	39.30	47.85
22	46.40	41.55	39.23	45.60	13	47.60	42.07	39.35	47.95
23	46.40	41.55	39.35	45.70	14	47.60	42.00	39.30	48.10
24	46.40	41.55	39.42	45.80	15	47.50	41.95	39.25	48.20
25	46.45	41.55	39.47	45.90	16	47.50	41.93	39.30	48.30
26	46.40	41.55	39.50	46.05	17	47.50	41.90	39.30	48.50
27	46.30	41.55	39 57	46.13	18	47.50	41.85	39.25	48.55
28	46.20	41 45	39.50	46.25	19	47.40	41.82	39.27	48.60
Mar. 1	46.20	41.35	39.40	46.30	20	47.40	41.82	39.32	48.70
2	46.30	41.37	39.40	46.20	21	47.40	41.82	39.35	48.70
3	46.30	41.43	39.45	46.30	22	47.40	41.87	39.33	48.80
4	46.50	41.55	39.54	46.35	23	47.40	41.84	39.30	48.95
5	46.70	41.75	39.64	46.40	24	47.30	41.82	39.40	49.05
6	46.90	41.85	39.82	46.45	25	47.00	41.50	39.27	49.10
7	47.20	42.20	40.00	46.60	26	46.70	41.30	39.05	49.10
8	47.30	42.40	40.19	46.70	27	46.40	41.00	38.90	49.05
9	47.50	42.51	40.34	46.85	28	46.10	40.68	38.70	49.00
10	47.40	42.51	40.45	46.95	29	45.90	40.45	38.52	48.85
11	47.50	42.60	40.50	47.10	30	45.70	40.30	38.40	48.70
12	47.80	42.85	40.75	47 30	May 1	45.60	40.20	38.25	48.50
13	47.90	43.00	40.90	47.75	2	45.60	40.10	38.15	48.35
14	48.00	43.03	40.92	47.80	3	45.60	40.15	38.15	48.25
15	48.20	43.18	41.05	47.95	4	45.50	40.00	38.05	48.25
16	48.40	43.35	40.83	47.70	5	45.40	40.00	38.00	48.10
17	48.60	43.45	40.67	46.65	6	45.30	39.85	37.87	48.00
18	48.70	43.40	40.55	47.50	7	45.10	39.70	37.85	47.80
19	48.70	43 10	40.40	47.40	8	44.90	39.55	37.70	47.60
20	48.70	43.10	40.25	47.20	9	44.70	39.35	37.63	47.40
21	48.80	43.15	40.23	47.10	10	44.50	39.15	37.45	47.30
22	48.80	43.20	40.27	47.05					

[Memphis datum.]

Date.	Rosedale, Miss.	Duvalls, Miss.	Date.	Rosedale, Miss.	Duvalls, Miss.	Date.	Rosedale, Miss.	Duvalls, Miss.
	Feet.	*Feet.*		*Feet.*	*Feet.*		*Feet.*	*Feet.*
Mar. 5	.....	108.90	Mar. 21	163.93	108.90	Apr. 6	.....	108.20
6	161.68	109.00	22	163.98	108.90	7	.....	108.35
7	161.88	109.00	23	164.03	108.90	8	.....	108.35
8	162.08	109.25	24	164.18	108.85	9	.....	108.35
9	162.18	109.45	25	164.38	108.85	10	.....	108.35
10	162.18	109.60	26	164.68	108.75	11	.....	108.35
11	162.28	109.70	27	164.78	108.75	12	.....	108.40
12	162.48	109.70	28	164.88	108.55	14	.....	108.45
13	162.58	109.95	29	164.93	108.45	15	.....	108.40
14	162.78	110.10	30	164.98	108.30	17	.....	108.50
15	162.98	110.15	31	.....	108.25	22	.....	108.50
16	163.18	109.80	Apr. 1	.....	108.30	24	.....	108.60
17	163.38	109.50	2	.....	108.25	28	.....	108.30
18	163.58	109.35	3	.....	108.20	29	.....	108.15
19	163.68	109.20	4	.....	108.20	30	.....	108.00
20	163.78	109.00	5	.....	108.20			

REPORT OF MR. E. C. TOLLINGER, ASSISTANT ENGINEER, ON THE HIGH-WATER PROTECTION OF LEVEES AND THE FLOOD OF 1890.

The following report of the care and protection of the levees of the Tensas Basin Front, Arkansas, and of the overflowed portions of Desha and Chicot counties, is respectfully submitted:

These levees were built by the State of Louisiana, its district boards, levee boards of Arkansas, railroad corporations, the United States Government, and private subscriptions. They have been built from time to time, without any established grade or proper care given to their foundations, selection of material, or cross-section. These have been enlarged and raised on old railroad embankments and private levees, without a thorough examination of the old structures, and the result is a poorly-constructed embankment to serve the purpose of levees. These levees have not been built on any well-considered plan, and no one seems to be responsible either for their size or location.

There was a more active interest taken in 1887–'88–'89, and considerable progress was made in building new and raising and enlarging the old.

During this period the grade was raised from Amos Bayou to Lucca Landing 3 feet, and from Lucca Landing to Arkansas City 2.5 feet above high water of 1882; from Arkansas City to Linwood 5 feet, and Linwood to Louisiana State line 3 and 4 feet above high water of 1888. (See tabulated statement herewith.)

The levees as raised were designed both as to height and dimensions of cross-section to pass only the highest water on the Arkansas City gauge previously recorded, as shown by the high water of 1882. Had this height not been exceeded, the levees, without doubt, would nave remained secure.

From Amos Bayou to Louisiana State line a large force was employed raising and strengthening weak places.

Through the high-water period, not 1 mile of the 90 miles of levee along the Arkansas front but required constant watching, day and night.

These levees in general are well protected from wave-wash.

Fifty miles required little more than day and night force to prevent stock from causing sloughs. Forty miles required a large force of laborers, day and night, to keep the levee intact.

This was notably so from Lucca Landing to Arkansas City, 9 miles, Arkansas City to Fulton Lake, 2 miles, and from Linwood to Vaucluse, 16 miles.

METHODS EMPLOYED.

First. To prevent overflow: Sacks of earth laid longitudinally on top of levee in tiers, one above the other, so as to break joints, or a wall of plank backed with earth.

Second. To prevent wave-wash: Sacks filled with earth and laid along at edge of water on side of levee, or other material when sacks could not be had.

Third. To prevent and repair sloughs: A shingling of levee with sacks of earth laid on a thick layer of brush, so arranged as to allow a free escape of the water, and supported at base of levee by a strong row of firmly driven and well-braced stakes.

Fourth. To lessen or stop seepage due to various causes: Loose earth dumped on the river side, or canvas laid in place and weighted down with sacks filled with earth.

Fifth. To stop breaks from widening: Many methods were employed, depending on the nature of the soil, height of levees, volume of water, location, accessibility, material on hand, etc.

The most satisfactory plan being a dike constructed of piles, brush, and sacks filled with earth. The piles are driven 10 or 15 feet in the ground, from 6 to 8 feet apart. A strong screen mat, made of willows or brush and trees, cut and put in place and safely secured with wire cables, is then sunk against the piling with filled sacks. This enables the construction of a dike of filled sacks to be made on the lower side of the piling. The dike usually begins about 100 feet from end of levees, and makes an angle with same of 70°, and extends from 75 to 100 feet into the current.

OVERFLOWED AREA.

Twenty days in advance of the maximum height reached at Arkansas City it was evident that breaks in the levees would occur. The timely notice given to the people living behind the levees, together with the small size of the crevasses in this section, enabled them to make provision for safety of themselves, their stock, and other property. No great suffering, loss, or destruction immediately followed the breaking of the levees.

Areas overflowed.

	Square miles.
Chicot County, overflowed	577
Chicot County, above overflow	133
Desha County, overflowed	546
Desha County, above overflow	100

Between Dumas and Varner (or 30 to 40 miles from Arkansas City), the overflow was 5 feet above the track of the Little Rock, Mississippi River and Texas Railroad.

The opinion prevailed that this water was discharged into Bayou Bartholomew, and thence south; a special examination was made which proved conclusively that there had not been any such discharge.

HIGH-WATER MARKS.

A number of high-water marks were made on trees at the time of the highest water, by driving in a 6-inch boat-spike marked H. W. 1890. These were placed about one-half mile apart, but this distance was reduced where cross levees and change of slope required. The elevation of these marks (about two hundred in number) have been determined and compared at important points with the high-water marks of 1882 and 1888. This table shows that the height of the flood of 1890, above that of 1888, was much greater above than below Arkansas City. The peculiar topography of the country between the Little Rock, Mississippi River and Texas Railroad, and the Arkansas River, and the construction of the railroad embankment itself, is probably the cause of this anomaly.

It is evident that the levees in this section will need an additional topping of 3 feet when compared with the increase of height at the lower end of the State, that may be required to pass future floods.

In order to give full protection to the country lying south of the Arkansas River, it will be necessary to extend the levee system from the mouth of Cypress Creek, across Caulk's Point, some distance up the Arkansas River.

Statement comparing high-water marks of 1882, 1888, *and* 1890, *and giving cross-sections of levees.*

[Elevations are from Memphis datum.]

Location.	High water, 1882.	High water, 1888.	High water, 1890.	Difference, 1888 and 1890.	Height of levee.	Width of crown.	Base of levee.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Amos Bayou	.....	155.76	161.10	5.34	161.4	4	30
Boggy Bayou	.....	155.00	160.84	5.84	161.5	4	96
Opossum Fork	.....	154.07	159.56	5.49	159.6	4	112
Lucca Landing	.....	152.05	157.31	5.26	158.9	4	64
Chicot	.....	150.28	155.61	5.33	154.7	4	52
Arkansas City	150.34	148.42	152.62	4.20	151.1	16	34
Gaines' Landing	.....	145.29	148.77	3.48	148.7	8	68
Linwood Landing	141.96	140.50	144.04	3.54	144.8	4	46
Luna Landing	.....	140.40	143.15	2.75	143.0	4	38
Vaucluse	.....	133.90	136.40	2.50	139.0	8	68
Sunnyside	.....	132.30	135.18	2.88	136.2	6	29
Lakeport	131.39	131.40	134.05	2.65	134.5	6	65
Grand Lake	.....	126.51	129.02	2.51	130.2	6	45
Hilliards	.....	125.61	128.31	2.70	128.4	6	27
Sterling	.....	124.28	126.55	2.27	127.3	6	26
Louisiana State line	.....	.....	125.55	.....	127.5	6	.....

Statement of amount expended for protection and repairs to levees of Tensas Basin Front in Arkansas, 1890.

Locality.	Pay-roll.	Subsistence.	Total.
Amos Bayou to Linwood	$13,906.46	$2,484.87	$16,391.33
Linwood to Vaucluse	8,416.89	1,103.56	9,520.45
Vaucluse to Lakeport	766.76	77.44	844.20
Lakeport to Louisiana State line	1,657.34	.....	1,667.34
One-third expenses steamer Etheridge, March and April	.....	.....	900.15
Total	24,757.45	3,665.87	30,023.47

The expense of charter of steamer *R. A. Speed* is not included in the above.
The cost of material used is also left out.

During the flood the strain on everybody who was engaged in an effort to hold the levees was excessive. Work was continued night and day.

At Arkansas City, 140,000 sacks were brought in on the railroad; most of these were used in front of the town, and the rest were loaded on barges and used north of Chicot.

As would be expected in an emergency of this kind, the work was an enormous cost, and the money would have been much better applied in raising and strengthening the levees before the high water.

The interval was too short to make the levees secure against overflow, even if unlimited funds had been at our disposal.

REPORT OF MR. HENRY GOODRICH, ASSISTANT ENGINEER, ON THE HIGH-WATER PROTECTION OF LEVEES AND THE FLOOD OF 1890.

In compliance with orders of March 23 and 28, directing me to take charge of the steamer *Osceola* and of the Government forces thereafter to be engaged in assisting the Fifth Louisiana Levee Board in protecting its line of levees from the Arkansas State line to Bedford's (opposite Warrenton), I now report completion of that service in the manner briefly stated below:

The first aid rendered by the *Osceola* was in transporting overflowed people and live-stock from the vicinity of Raleigh Break to nearest dry ground, and in delivering forces and material (lumber, sacks, and bagging) for protecting levees to the places endangered.

In co-operation with the president and engineer of the Levee Board, who generally accompanied me, plans of work were adopted and organized forces started where most needed along the line, as given below. To enable me to judge of the necessity and kind of work to be done, to organize forces, and to pay for labor performed, the *Osceola* was kept constantly in use, visiting all points of danger and rendering the needed aid. On two occasions, by your special permission obtained, at the time of highest flood and greatest danger to the line below Bedford's, the *Osceola* went as far down as St. Joseph and Concordia Break to deliver a pile-driver for use in preventing the widening of gap. In this connection it may be mentioned that a fleet of several willow barges, mattress barge, rock barge, stock barge, coal barge, and pile-driver, were kept in readiness at Alsatia for use in emergency.

At each end of Raleigh Break a willow mattress was made to protect them from widening; but constant care needed to be given in supplementing them with willow bundles, weighted with sacks of earth, between each end and its mat.

The swift lateral return-current in the overflow against the levee threatened to wash it seriously, and had to be deflected by spur dikes of timber and planks. The mattresses also had to be similarly protected on the upper side from the erosion of the strong current down along the levee, setting in toward the break.

A brief sketch of the condition of the line of levees at the beginning of the present high water, and mention of the recent work accomplished by the Louisiana State Boards, are here added as explanatory of the situation. Prior to Government aid this season they had expended a very large sum in systematic raising and strengthening the line planned for the entire fifth district, accomplished in scattered portions only, and interrupted by the early and long continued high water.

But for this timely preparatory work of enlargement to better grade and section, as State funds permitted, the struggle for maintenance of line against this unusual flood-wave would have been, without doubt, far more perilous even than it was.

From Filcher's Point to Wilson's the river raised 3½ feet higher than observed at any previous year, and left the levee a very small margin of about a foot above water.

At Lake Providence the increased height was 2.6 feet higher than in 1882.

Two large new levees, Raleigh and Longwood, were in process of construction for the State, to replace old front lines which were about to cave off.

Protection loops at each of these places had to be built as the caving continued, to restrain the river and to allow time for finishing the main line, and were themselves held with great difficulty and cost till that object seemed accomplished.

At Raleigh the main line was closed only a day before the loop caved off (February 30, 1890).

A sudden rush of water filled up against the new embankment an average depth of 9 feet, causing sudden and unequal saturation and irregular settling, all the greater on account of mixed material, silt and sand, heaped up by wheelbarrows about 12½ feet high.

The portion first built, the north end, had appeared solid and safe, and least of all was suspected of breaking.

A general settling of material had taken place, but to outward appearance, at the

place which broke, the shape and proportions were better preserved than elsewhere, and had called for no extra work.

Without premonition of special weakness, the land slide slipped with sudden softening from saturation. This induced a rush of semi-fluid material, by hydrostatic pressure, and the river followed.

In a few days the break had widened to 4,500 feet, and since then has been held in check by end-protection.

The break occurred at 5 p. m. March 15; gauging was made April 12. The actual stage of river at either date could not be then referred to any standard datum on account of the inaccessibility of benches, but will be reported later.

A single discharge observation by a score of located soundings and surface velocities, as given in separate report, gave an average depth of 13.3 feet, mean reduced velocity 2.7 feet per second, width 4,600 feet, and consequent discharge of 166,000 cubic feet per second. The location of the crevasse was within the first or upper mile of the new levee.

The average net dimensions of levees in north Louisiana are in height at present 10 feet (from 7 to 13), with crown 6 feet, and slopes 3 and 2 to 1, the longer slope on the river side.

New lines have higher grade and larger sections, crown 8 feet, slopes 3 and 3 to 1, when sufficient funds for construction are available.

An additional rise of 1 foot this season would have hopelessly overtopped miles of levee more than could have been maintained successfully under all the disadvantages of the season.

As a fact, the actual height of raising the old grade, after the high water came, was in many portions nearly 2 feet, with very little margin above water.

The places at which Government aid was given, under my direction, besides the Raleigh break, were generally:

First. High, steep, narrow levees, thoroughly saturated, and about to slide or slough.

Second. Narrow-topped levees badly wave-washing, and about to be cut through.

Third. Low levees about to be overtopped.

Fourth. Leaking levees, perforated and endangered by crayfish holes, trickling, muddy water and sand, from interior cutting.

Fifth. Exposed levees, eroded by strong impinging currents.

Sixth. Combination of these conditions.

The methods of adding strength to weak and insufficient levees are as various as the particulars of individual weakness, and suggest themselves under special conditions.

A slide or slough can generally be successfully checked by placing willow brush upon the slope, limbs upward, weighted near the base with sacks of earth and by a plank, well braced.

The willow twigs serve to drain off the saturation and at the same time to support the material.

Worse cases need enlargement of section under water, to restrain percolation and seepage, a most efficient and successful remedy, especially in places remote from the action of strong currents.

Still worse cases require not only the foregoing treatment, but an additional land-side section built up from a secure retaining-wall of plank, of dry earth, or, still better, with sacks of earth.

Wave-wash can be checked by a plank-wall, or sheet-piling, or, still better, with sacks of earth which readily remain where placed. If the washing has just begun on a long stretch, common jute bagging, unrolled and well staked down, will arrest the force and damage to a considerable extent.

A sand boil, or crayfish-hole, discharging sand and mud, can often be smothered by weighting the corners of a square of bagging over it so as to strain off the water and retain the material, to obstruct the flow.

Often a weighted barrel or large cylinder placed over it has been used to catch the flow till it stopped by equalized pressure.

Exposed angles of levees are best protected by spur-dikes of plank, in connection with willow bundles, weighted with sacks of earth, and secured by ropes or wire to the solid embankment.

Draining from the base the surface accumulation will greatly aid in maintaining a saturated embankment.

The tramping of cattle, as in grazing on the levee-slope, during the season of high water invariably causes trouble, and often disastrous consequences.

The ends of crevasses can best be protected by deflecting the currents from them by a row of thickly-driven piles as a spur-dike, projecting from each end at a gentle angle into the current, and sinking bundles of weighted willows against the piling to obstruct flow.

Crevasses commonly occur from some of the causes of weakness above enumerated,

intensified by faulty construction as to preparation of base, selection of clean material, tamping of mock ditch, etc.

With sufficient funds, the dimensions of sections, in every respect, should be increased by a liberal factor of safety, and a few new specifications added to those now commonly adopted, looking to the better construction and location and preservation of levees by systematic, annual, and studious care.

An unhesitating preference should be given to scraper work over wheelbarrow, where location permits, as it results in a compact embankment, with better chances of withstanding saturation and unequal shrinking, even though subject to superficial criticism of washing more from severe rainfall, a loss that is far more than counterbalanced by compactness.

In directing the work under my charge, as Government aid towards restraining the river within its training walls, I have undertaken only such work as I deemed necessary, and have limited it to its minimum of labor and cost.

LABOR STATEMENT.

Location and cost of work by United States forces, in protection of north Louisiana levees, from Ashton to Bedford's, March, April, and May, 1890.

Locality.	Labor.	Total pay-rolls.	Remarks.
	Days.		
Millikin's Bend	1,195	$1,837.70	Stopping sloughs, wave-wash, topping.
Omega	508	664.65	Stopping sloughs, wave-wash, topping.
Raleigh Break	1,448	1,985.73	Mattressing and revetting ends.
Buckhorn	609	677.35	Stopping sloughs.
Bedford's	333	469.36	Do.
Bunch's Bend	40	47.45	Stopping erosion of current.
Longwood	63	73.64	Stopping wave-wash.
Blue Ridge	273	390.86	Stopping sloughs.
Pecan Grove	110	155.63	Raising top and strengthening.
Henderson	64	72.70	Stopping erosion and wave-wash.
Survey	23	87.90	Making overflow reconnaissance.
Osceola pay-rolls	1,123	2,416.46	Salaries of officers and crew on steamer *Osceola* and on overflow.
Subsistence, supplies, and traveling expenses.		291.27	Reconnaissance.
Total	5,789	9,170.70	Not including cost of fuel for *Osceola*.

Information through reconnaissance parties, relative to the extent of the flooded territory, traced with care, has been obtained, and the elevations of high water marked and described, and will soon be evaluated in reference to Memphis datum plane.

This information will be the subject of a separate report, and contributed to the comprehensive report and map of the entire third district, Mississippi River Commission, now in progress.

The aid rendered in my special subdistrict has been timely, necessary, economic, and successful.

Leaving out Raleigh break (which occurred prior to the national aid), there has been no mishap on the line on the west bank from Ashton to Bedford's, though numerous threatening dangers from time to time have been met and remedied.

The following report, submitted to the committee on resolutions of the Mississippi River improvement and levee convention, which met at Vicksburg, Miss., on April 30, 1890, is quoted as bearing directly upon the history of the flood of 1890:

REPORT OF ENGINEERS.

VICKSBURG, MISS., *April* 30, 1890.

To the Committee on Resolutions of the Mississippi River Improvement and Levee Convention:

Your committee, to whom was assigned the duty of preparing a statement on the subject of levees, beg leave to submit the following:

The testimony of all engineers familiar with the subject is that there is no engineering difficulty in the way of restraining the floods of the Mississippi River through the agency of levees, and that this is the only agency through which that object can be accomplished. The levees, as they existed at the beginning of the recent flood,

were admittedly too weak generally, in heighth and width, to stand an extraordinary high water, as was recognized and affirmed by all levee engineers.

The fundamental defect in the present system of levee building is that they have not been designed and constructed on engineering principles in the most thorough manner, with the sole view to certain efficiency, as is the case in all other classes of engineering work; but it has always been a mere question of doing the best that could be done with an insufficient amount of money.

The great desideratum has been to pile up as much dirt as possible in the cheapest possible way, so as to cover the greatest extent of territory with the highest bank of earth attainable with the means at hand. This consideration has precluded such treatment of the foundations as the character and service of the structures demanded, to which deficiency is attributed much of their failure to successfully resist the extraordinary pressure of this flood at various points. The disasters from the recent flood have been exaggerated and magnified beyond their true proportions by the sensational treatment which the subject has received, and which has tended to shake confidence in the efficiency of the levee system.

In confirmation of this attention is invited to the following facts: In 1882 the total number of crevasses in the levees was 284, aggregating 56.09 miles in width; in 1883 the number of crevasses was 224, with an aggregate width of 34.1 miles; in 1884 the crevasses numbered 204, aggregating 10.64 miles in width.

The result of the crevasses enumerated during these three years was a general overflow of the Mississippi Delta. In the present flood, the dangers of which are nearly passed, the crevasses which have occurred numbered twenty-three, aggregating about 4¼ miles in width, in a total length of 1,100 miles of levees, or less than one-half of 1 per cent. of the total line of levees, notwithstanding that the present flood has exceeded those of the three years cited in the height attained at Memphis and all points below, and has not been exceeded in duration. This excess of height was, at Memphis, 0.5 foot; at Helena, 0.6 foot; at Sunflower Landing, 1.2 feet; at Arkansas City, 2.3 feet; at Greenville, 1.7 feet; at Providence, 3.1 feet; at Vicksburg, 0.1 foot; at Natchez, 0.8 foot, and at New Orleans, 0.5 foot.

The general result has been a large measure of protection afforded by the levees this year, notwithstanding the extraordinary character of the flood, which has never been enjoyed during previous high waters of considerable magnitude.

For example, in the Yazoo Basin between 80 and 85 per cent. of its area is protected from overflow, there being only one crevasse of 280 feet in width, affecting a very small area, in 180 miles of levee, extending from the upper extremity southward. There were other crevasses on this front below this locality. On the Tensas front are two reaches of continuous levee, being respectively 81 and 125 miles in length. The right bank below Red River has 180 miles of continuous unbroken levee, and the left bank has 200 miles with only one break. Of the territory dependent upon the last-named levees, 75 per cent. has been protected. The percentages of areas protected as above noted embrace all classes of lands subject to overflow; as the lands sought for cultivation are the more elevated portions, the percentage of their area protected is much greater.

From our knowledge of this subject we now feel justified in declaring that very great progress has been made during the past five years in the construction of a complete levee system by the joint efforts of the General Government and the riparian States; and also that the experience of the present flood has strongly added to our conviction that such a system presents the only solution of the protection of the alluvial valley from inundation in connection with the general improvement of the river. We unhesitatingly express our condemnation of all theories for the regulation of the Mississippi River and controlling its floods by the agency of "outlets." It is our conviction that such a system would prove destructive to all the interests which are sought to be conserved and improved in connection with the treatment of the Mississippi River. We also state with thorough conviction and emphasis that the belief entertained by some that the effect of long confinement of the Mississippi River by levees will be to produce a permanent elevation of the river bed is a fallacious one, which is refuted by experience and contrary to all observation. We are familiar with all surveys that have been made of the Mississippi and with its present navigation, and declare that there is no evidence from either of these sources or elsewhere of progressive elevation of the bed of the Mississippi River from levees or other cause, except where caused by and immediately below outlets.

We submit the following information relating to expenditures upon the levees from the following sources:

By the United States Government, through the Mississippi River Commission since 1882	$3,018,601.50
The Mississippi levee boards since 1882	3,098,745.74
State and levee districts of Louisiana since 1866	15,255,327.13
Of which since 1882 about	5,000,000.00
Arkansas	340,417.00

The above do not include expenditures which have been made by counties, corporations, and individuals in the several States. We estimate that a further expenditure of $10,000,000 by the General Government, in co-operation with the riparian States, if promptly applied, will suffice to complete a system of levees that will prove entirely effective to restrain all future floods of the Mississippi River.

J. H. WILLARD,
Captain Engineers, U. S. A.
W. YOUNG,
Captain Engineers, U. S. A.
B. M. HARROD, C. E.
S. W. FERGUSON, C. E.
HENRY B. RICHARDSON, C. E.
WM. STERLING, C. E.
T. G. DABNEY, C. E.
H. S. DOUGLAS, C. E.
ARTHUR HIDER, C. E.
H. BOLIVAR THOMPSON, C. E.
H. ST. L. COPPÉE, C. E.
JNO. SMYTHE, C. E.
HENRY GOODRICH, C. E.
JNO. EWENS, C. E.
GEO. M. HELM, C. E.
HORACE MARSHALL, C. E.

AMELIA, ARK., *May* 3, 1890.

MY DEAR SENATOR GEORGE: I fully indorse the report of the engineers to the Vicksburg convention as to the efficiency of a proper system of levees and the futility of all other proposed plans for preventing overflows. The most hopeful thing which has occurred within my knowledge of levee history is the remarkable endurance of the present weak line in the face of the late enormous flood.

Very truly, yours,

SMITH S. LEACH,
Captain of Engineers.

Hon. J. Z. GEORGE.
United States Senate.

The following extracts, taken from a late report (date April 23, 1890) of Maj. William Sterling, chief engineer of the board of Mississippi levee commissioners, are, by permission, quoted, as bearing directly upon the history of the flood of 1890:

REPORT OF CHIEF ENGINEER.

ENGINEER'S DEPARTMENT,
BOARD OF MISSISSIPPI LEVEE COMMISSIONERS,
Greenville, Miss., April 23, 1890.

* * * * * * *

This flood must unquestionably take rank among the very great ones, with 1858, 1862, 1867, 1882, and 1884. It was not, perhaps, of greater duration than the first, nor was the maximum quantity of water at any one time as great as in the last two, nor was it in any respect as formidable as 1882, but it is probable that, taken all together, it was not exceeded by any except 1882.

It proceeded mainly from the Ohio and its tributaries, aided materially by a very high stage, maintained with great constancy, in White River, and several considerable rises from the Arkansas.

There were no less than six rises in the upper Ohio, which were met by freshets from the Cumberland and Tennessee, resulting in four distinct rises at Cairo, culminating at stages of 43.7, 41.8, 48.9, and 48.8 on the gauge at that place. The intervals between these rises were so short that the corresponding falls never reached the lower part of our district, being overtaken in each instance by the succeeding swell. Consequently the strain was first felt in the extreme southern portion of our line, where a very high stage was attained while the upper division was enjoying perfect security.

At Skipwith's the river in February was 1 foot above 1882, while at Australia it was 2 feet below, and while at Helena the gauge marked 4 or 5 feet below the record of that year. This condition of things gradually changed. The third and fourth rises brought the Helena gauge to 47.7 and 47.5, respectively; 0.5 and 0.3 above 1882,

and 0.4 and 0.6 below 1886. The strain was now transferred to the upper part of the line, the lower part having been relieved in the mean time by the crevasse at Raleigh, in Louisiana.

The condition of our line at that time was as follows:

In pursuance of the plan of enlargement approved by the board, some portions of the upper end of the district had been brought to standard, that is, to a grade 3 to 3½ feet above the highest water recorded, usually 1886, sometimes 1882, a crown of 8 feet, and slopes of 3 to 1 on each side. Some other portions of the line had also been brought to this standard, namely, all the new levees constructed during 1888 and 1889, and some little enlargement work, the programme being that henceforth wherever new work or enlargement was undertaken at all, it should be brought to these dimensions.

The other portions of the line as far down as Mound Landing were built to a grade 3 feet above high water, a front slope of 3 to 1, and a crown of 8 feet, the back slope being left unenlarged for the present.

Below Mound Landing the grade heretofore adopted was 5 feet above 1888, the standard of that year. Owing to the insufficiency of our means, in order to attain this height over as large a part of our line as possible, the crown was made only 2 feet, it being intended during the coming year to increase this to 8, and the grade to 5.5 above 1888.

The reason that 1886 and 1888 were respectively adopted as the standards above and below Mound Landing was this:

It is known that a moderate flood is no criterion at all for a high one. Even at high water is not an accurate criterion for a higher one, as will be presently seen. Nevertheless, the best we can do is to select the highest attainable record as a basis, unless some other consideration intervenes. Now, 1886 was not nearly so great a flood as 1882 or 1884, but it was more closely confined, by the rebuilding of the levees in the upper district of the Mississippi and the partial rebuilding of the Arkansas line. Therefore, it attained a much greater height at Helena than in 1882, and was also considerably higher for long stretches of the upper part of our line, notably in the vicinity of Catfish Point. Moreover, the high-water line of that year had the great advantage of not being vitiated by numerous crevasses. Wherefore, it was adopted, except where it was exceeded by the mark of 1882, in which event, for greater safety, the latter was made the standard.

Below Mound Landing, however, the line of 1886 was no longer trustworthy, on account of the number of breaks in the Arkansas levees. The first year in which the water of the river was entirely confined between levees from Arkansas City to Vicksburg was 1888, and it so happened that for a considerable portion of that reach it equaled or exceeded the greatest previous record, with the exception of 1862, and the records of that year are so fragmentary and uncertain that they can only serve as a check or a warning and not as a guide. Therefore, below Mound Landing the high water of 1888 was made the standard, and the grade fixed at 5 feet above that line. At the same time, the opinion was expressed (see my report of May 14, 1889) that this grade was not safe in itself, but relied rather on the weakness of our neighbors across the river, which weakness was continually diminishing, and, as the result abundantly shows, was not to be depended on at all.

Previously to 1888 the high-water fight had always been above Mound Landing. The levees in Washington and Issaquena counties had practically given but little trouble. The almost unleveed front of Arkansas directly opposite us acted as a waste-weir, and the water could not attain more than a certain height, be the floods never so great. The quantity of the total flood discharged over this bank of course increased as we go down the river, the portion thus lost being, in 1886, we will say, at Arkansas City about 10 per cent., opposite Greenville about 20 per cent., at Ashton about 35 per cent. of the whole discharge of the river. There were no precise observations in 1886. These approximations are very rough.

The rebuilding of the Arkansas levees in 1887 put a new face upon matters, and the high water which prevailed in the lower part of our district during the very moderate flood of 1888 indicated the urgent need of greatly increased dimensions for our levees in that portion of our line. For the last two years, therefore, our main strength has been thrown on the enlargement of the levees in Washington and Issaquena counties, and they have been given all the dimensions that our means would permit.

Under the conditions mentioned above the first trouble experienced was at the lower end of the district, where portions of the levee were deficient. This was partly due to the fact that the contracts in force did not extend entirely throughout the district, partly to the unfinished state of these contracts. In the case of the enlargements the contractors were caught by the rising river before the time limited for the completion of their work. In the case of the new work, namely, the Clover Hill and Hall's Landing levees, it was partly the misfortune of the contractors in adverse weather and insufficiency of labor, and partly their fault, that their levees were not completed at the stipulated time.

As it was, no disaster happened in the case either of the new work or the enlarge-

ment of the old. Owing to the exertions of Mr. Hyner and Mr. Marshall, the former were completed in time enough and the latter were topped to a sufficient height. On the 10th of March the levee at Raleigh, La., gave way and in a few days caused a fall in the water-surface of the river varying according to situation and amounting, in the immediate vicinity, to about a foot and a half. The scene of danger was now shifted, it was thought, from the lower to the middle part of the district, the extreme upper part being yet comparatively safe. The principal cause of apprehension here was the lowness of some of the levees, which were threatened with being actually overtopped.

* * * * * * *

It was found that the work of securing the ends of the breaks where the crevasse was of very recent occurrence, the levees high, the material light, and the current strong was a very serious undertaking, and the methods formerly practiced, of direct revetment by sacks, brush, etc , of no efficacy at all. Resort was then had to a method first practiced, so far as I know, by Mr. H. M. Marshall at Grand Lake in 1888, of building spur-dikes near the broken ends and thus throwing that destructive portion of the current that runs parallel to the levee further out and beyond the ends. Mr. Marshall's dikes were made of brush and sacks. In the deep water in which we were obliged to work it was thought better to adopt the modifications practiced with great success by Mr. Atkins in Arkansas, of driving piles, or utilizing trees where they existed, and lodging brush against them, and, under cover of this protection, building walls of sacks. This method, which is susceptible of endless modifications, has been successful wherever adopted.

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The manner in which these breaks occurred, so far as is known, has always been the same. They went from the bottom. In no instance were the levees overtopped by the water. All except the Huntington Levee were comparatively new works; the Offutt Levee having been built in 1879, the Skipwith and Easton levees in 1882–'83, and the Catfish Point Levee in 1886. This fact, together with the manner of the break, pretty much excludes the supposition of unsoundness or cavities within the body of the levee. Two of them, at least, were built through open fields, where there was no timber. In every case in which the break was observed the cause was evidently under the levee and not in it, the break taking place in the natural surface, on the land side of the levee. These circumstances point with a probability which is almost certainty to the conclusion that the weakness lay in a sandy stratum, either immediately beneath the levee or only a short distance below the ground. This soil is of a much looser consistency than that of the levee itself, since the latter is packed, while the former is spongy and permeated with roots, pores, and fissures. If the borrow-pits extend into this stratum, and it be consequently exposed to the enormous lateral pressure of water at a great depth, continued for weeks and months, it becomes thoroughly infiltrated with water and reduced to an almost semi-fluid condition, being thus capable of partially transmitting a hydrostatic pressure. The weight of the levee is sufficient to withstand this pressure, but it is exerted with destructive effect on the thin crust of natural soil, just inside of the levee, and bursts it up. I once saw such a break, and the above reasoning forced itself upon me with strong conviction; and the description of the breaks at Huntington and Catfish Point, from eye-witnesses, tallies precisely with my own observation. That the other breaks proceeded from the same cause can not positively be asserted. There has been some talk, since the break at Offutt's, of a hole in a drainage-ditch inside the levee, but I have not myself seen the witnesses of this, and do not know how much importance to attach to their testimony. A hole of this kind may be of great consequence, or none at all, according to circumstances. In each instance the existence of a light sandy stratum at or near the surface of the soil is notorious, and all the circumstances favor the supposition that it was the sufficient cause of all the crevasses. Another would probably have occurred at the hoop, above Major Edmond's, had it not been for Mr. Somerville's and Major Redmond's prompt and timely action, as the soil on the land side of that levee had already begun to bulge upwards. Doubtless it would have burst had it not been heavily weighted.

This element of weakness had long been known to me, but it was thought that the dimensions given to our levees, sanctioned as they were by long experience, were sufficient to overcome it. It is now evident that they were not. Even, however, if it had been known that such was the case. it would have been ont of our power to avert disaster. Our levees were nowhere superfluously strong or superfluously high and whatever labor was bestowed on strengthening lines now known to have been weak must have been diverted from other points where it was almost equally necessary. Had these or other breaks not occurred at the time they did, the river must have gone much higher. We might have been overtopped, for there was much levee that lacked but little of letting the water over it. Had we, by diligent labor, escaped that danger, and topped the deficient places to a sufficient height, yet it was not in our power

to give them proportionate strength, and our disasters, bad as they are, might have been far worse.

The occasional deficiencies in grade to which allusion has been made are due to the fact that no one flood is an accurate criterion for another. When, therefore, we build our levees 3 feet higher than 1882 or 1886, or 5 feet higher than 1888, we do so with the perfect knowledge that when a much higher water comes it will not be uniformly higher all along the line. But we can not, till engineers become omniscient, tell where all the discrepancies will occur or how great they will be. At one point the water will be perhaps 2 feet higher than the standard, at another 3; thus at Skipwith's this year it was nearly 3½ feet higher than 1882 or 1888, while at most other parts of the line it was only 2½, and that, too, before any breaks had occurred. The causes of some of these discrepancies are known and have been provided against. This particular instance is a type of several that have occurred this year, and appears due to a cause not heretofore suspected, by me at least, for the reason that I have never before seen a flood high enough to bring it prominently into play, and that is the movement of large masses of water across unleveed points. Above Skipwith's the long point called Sarah's Island lies outside the levee, and the water has a free course over it. This movement, then, as far as it goes, acts like a cut-off, lowering the water-surface in the bend above the point, while it raises it in the bend below. This was strongly exemplified by the break at Connelly's on Catfish Point, which lowered the water-surface at Bolivar by about a foot. Suppose instead of a break 2,000 feet wide the levee had been entirely washed away. The depression at Bolivar would have been still greater. The situation would then have been precisely that of an unleveed point, and the water-surface in Choctaw Bend below would have been raised as a cut-off.

This cause acted also in other floods, but to a much less extent. It makes a vast difference whether water runs across a point 2 feet deep or 5 feet deep, the velocity increasing enormously in the latter case. Therefore, while in 1882 or 1888 the water-surface at Skipwith was somewhat raised from this reason, in 1890 it was raised disproportionately more. At Neblett's Landing and at the lower end of the Miller's Bend Levee the same conditions prevailed, and the same phenomenon was observed. In the one case the flow is across Indian Point and in the other across Ashbrook's Point. In each instance the levees appeared unduly low, but they were not. The water was unduly high.

February and March, and even the earlier part of April, were marked by the prevalence of unusually high winds. Here, too, the influence of the extraordinary stage of water was felt in submerging deeply lands heretofore overflowed slightly, or not at all, and exposing to wave-wash levees formerly deemed altogether exempt from that danger. This was particularly observable in the lower part of the district, where, consequently, we had prolonged and repeated fights against the winds, necessitating the use of vast quantities of sacks. Most of these fronts will hereafter have to be protected by revetments or breakwaters of some kind.

The high-water expenses have been proportionate to the magnitude of the flood, and I fear they will be found unprecedentedly great. Everything has been done that seemed practicable to prevent waste and unnecessary work, but with only limited success. Organized forces have been used to a considerable extent, and I think it will be found advisable in future great floods to make still more use of them, and, in fact, as far as possible, employ them altogether in high-water work.

It is yet far too early to present accurate estimates of the work which will be required to replace that which has been lost, still less is it possible, at this time, to calculate the increase of grade which will be necessary to bring our levees to a safe height. There will be ample data for such estimates when the high-water observations are all reported. These will be unusually full this year. The Government has out numerous parties measuring the discharge of the river at various points; among others, at Helena, Arkansas City, Wilson's Point, and Vicksburg, as well as at the several crevasses on both sides. Two very complete series of high-water marks have been taken by our own organization, one at the top of the second rise before any breaks had occurred, the other at actual high water. These marks were taken at every mile. It is hoped that it will be possible, from all these data, to fix with considerable accuracy upon a safe grade. One thing is sure, that our levees will have to be raised 3 feet to hold a flood like 1882, and allow any proper margin for contingencies. This, at a rough estimate, will require 10,000,000 cubic yards; to rebuild the gaps, about 500,000. The fact that our levees have given way in unexpected places, and in an unexpected manner, should not lend any color to the vulgar notion sometimes expressed that no confidence can be placed in levees, or as it is sometimes phrased, that "dirt can not be made to hold water." On the contrary, the experience of this year shows that by far the greater portion of our earth-works have stood a strain, which for magnitude and duration is utterly beyond precedent, with wonderful tenacity. If they have sometimes failed, it was because there was a good reason for it, and

so far from being discouraged, we should be stimulated to find out the cause and apply the remedy.

I think the cause has been discovered. The remedies may be threefold. First, to make borrow-pits, shallower, where sandy soil prevails, to keep them if possible from extending to the sand stratum at all; if not, to leave a berme of unusual width between them and the levee. Second, to dig a muck ditch of much greater width and depth than usual, penetrating entirely through the sand stratum, if practicable, and filled with buck-shot earth thoroughly tamped. Third, to build a banquette or bench on the land side, of sufficient width and height to hold down the upward pressure, and transfer it to a point where it will be so far weakened by distance and constant resistance as to be harmless. There is no question that the difficulties in the way of building sound and sufficient levees have been underrated. We have gone at the work in a rough-and-ready way, each man following in the footsteps of his predecessor, holding blindly to a rule-of-thumb method, without close inquiry into differences of circumstances. Slopes of three to one, with a crown of 8 feet, have been supposed to make a safe levee in any kind of soil. So far as the levees are concerned perhaps they do, but they do not afford a sufficient cover to a weak and treacherous foundation. A more minute and intelligent supervision will be henceforth necessary, and a stricter adherence to specifications.

The details of these matters must be reserved for more careful study.

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Respectfully,

WM. STARLING,
Chief Engineer.

REPORT OF MR. J. J. HOOPES, ASSISTANT ENGINEER, ON DISCHARGE OBSERVATIONS AT ARKANSAS CITY AND AT THE VARIOUS CREVASSES IN THE THIRD DISTRICT, 1890.

I submit herewith the results of the discharge observations at Arkansas City, and also gauging of the volume or water passing through the crevasses in the vicinity.

The party was organized March 6, 1890. The appliances were put in order and range signals relocated. The old discharge section was used in these observations, and as the intersecting signals were nearly all carried away by the high water, and the banks were overflowed, careful surveys were required to mark the ranges in their old positions. The first complete set of river-discharge measurements was made on March 14 and the last on April 15. In all fourteen complete gaugings were obtained, covering the time of highest water.

Two partial discharges were taken, which could not be made complete, owing to, in one case the failure of appliances, and in the other to obstruction of view, caused by ferry-boat *Marian*, lying at elevator. The accident to the *Vidalia*, and failure in appliances, made it impossible to obtain a discharge between March 19 and March 25, and the wind-storm of March 27 interfered on that date. More discharges would have been taken had the steam-boat been available, but the urgent necessity for its use in preserving the levees, and relieving the people overflowed, interfered with the use of the boat for this purpose.

CREVASSES.

The crevasses above the discharge section on the Mississippi side were Catfish Point, Easton, and Huntington, through all of which the water flowed from the river, and ten crevasses on the lower side of Catfish Point, through which the water flowed into the river from the break at Catfish, on the upper side of the point. The Offutt crevasse was below the discharge section.

The crevasses on the Arkansas side, above the discharge section, were at Brooksfield, Boggy Bayou, Sappington, Fergusom, Chicot, and one between Chicot and Arkansas City. The last-named flowed into the river after March 27.

With this exception the water from the other crevasses on this side and that flowing around the end of the levee at Amos Bayou is all discharged between Arkansas City and Trippe through and over the embankment of the Little Rock, Mississippi River and Texas Railroad.

The distance from the river-discharge section to Trippe is 7 miles. Three careful measurements were made of this discharge, which, as stated above, includes all the water passing through the crevasses on the right bank above the discharge section. The following is the method used in gauging the crevasses. The water flowing through Huntington and Catfish Point crevasses was measured with the current-meter.

Of that flowing through others, the velocity was obtained by the use of floats,

except a portion between Arkansas City and Trippe, being of small depth and flowing over the railroad embankment; the flow was treated as passing over a weir.

The floats used were two cones, each 6 inches in diameter and 6 inches high, joined at their base, and submerged to mid-depth. The time of passing two ranges of known distance apart was taken and the surface velocity computed.

In other instances the time taken for the float to travel the length of the skiff was used where ranges could not be obtained on account of backwater, the skiff being held in position by a line fastened to a tree. Eighty per cent. of the surface velocity was taken as the mean velocity.

The maximum discharge of Huntington crevasse was calculated from data obtained on April 1, but which was not complete, on account of the current being too strong to allow a complete set of soundings.

That of the crevasses on the lower side of Catfish Point was found by taking the increase of area resulting from the caving back of the ends of the levee, combined with the velocities found in the previous observations of March 12.

The maximum discharge of Offut's crevasse is from estimation 600 feet long, 7 feet deep, with velocity of 8 feet per second, as the first measurements, April 15, were not obtained until after the water had begun flowing back into the river, which began April 1.

In estimating the maximum discharge of Boggy Bayou, the original depth of the levee below the water-line, the width found in later observations, and a velocity of 7 feet per second were the data taken. A velocity of 6 feet per second was used for the Chicot, Brooksfield, and Ferguson crevasses.

The date of maximum discharge was generally taken at about three days after the break, as after that time the backwater retarded the flow through the crevasse.

The results obtained, with the locality and dates upon which measurements were made, are contained in the accompanying statement.

Method: The main river discharges were obtained from a steam-boat, with a current-meter, in the usual manner.

Eleven velocity sections were taken, and the soundings across the section spaced generally less than 75 feet apart; these were located by a transit stationed on the right bank, about 2,000 feet above the discharge section.

RATING CURRENT METERS.

Price meters Nos. 4 and 6 were used on the work. The former was rated twice and the latter once. All the observations for rating them were taken at Lucca Landing, in still water, over a base 1,000 feet long; about a dozen observations being made in each rating.

A steam-boat was used in this work, and the velocities ranged about 3 to 10 feet per second.

Results of discharge observations, Mississippi River, Arkansas City, Arkansas, 1890.

Date.	Area.	Gauge.	Difference.	Resulting difference in water areas.	Actual difference in water areas.	Scour +; Fill —	Datum area.
Mar. 14	206,615	48.00	.....	.....	.....	.....	184,568
19	222,638	48.66	+0.66	—2,257	+16,023	+13,766	198,342
25	225,579	49.01	+0.35	—1,197	+ 2,941	+ 1,744	200,090
26	228,326	49.22	+0.21	— 718	+ 2,747	+ 2,029	202,122
28	218,791	49.05	—0.17	+ 581	— 9,535	— 8,954	.....
30	231,370	48.62	—0.43	+1,470	+12,579	+14,049	207,211
31	227,722	48.66	—0.06	+ 205	— 3,647	3,443	203,767
Apr. 2	230,119	48.41	—0.15	+ 513	+ 2,397	+ 2,910	206,675
4	226,695	48.08	—0.33	+1,128	— 3,424	— 2,296	204,376
7	223,193	47.71	—0.37	+1,265	— 3,502	— 2,237	202,135
9	226,274	47.78	+0.07	— 240	+ 3,081	+ 2,841	204,977
11	233,503	47.70	—0.08	+ 274	+ 7,229	+ 7,503	212,497
13	241,545	47.60	—0.10	+ 342	+ 8,042	+ 8,384	220,861
15	237,359	47.55	—0.05	+ 171	— 4,186	— 4,015	216,846

Results of discharge observations, Mississippi River, Arkansas City, Arkansas, 1890.

[Width, 3,420 feet.]

Date.	Gauge-readings.	Gauge difference.	Dimensions of discharge section.			Scour + or fill—	Mean velocity per second.	Discharge per second.	Discharge outside of section.	Total discharge per second.
			Area.	Mean depth.	Maximum depth.					
Mar. 14	48.00	0.00	206,615	60.4	83	.....	5.714	1,180,659	5,000	1,185,659
19	48.66	+0.66	222,638	65.1	88.5	+18,214	6.335	1,410,441	8,000	1,418,441
25	49.01	+0.35	225,579	65.96	89.5	+ 4,138	5.364	1,210,124	10,000	1,220,124
26	49.22	+0.21	228,326	66.8	86	+ 2,465	5.685	1,298,010	10,000	1,308,010
28	49.05	—0.17	218,791	64.0	89	−10,116	5.544	1,212,919	10,000	1,222,919
30	48.62	−0.43	231,370	67.7	92	+11,109	5.369	1,242,231	8,000	1,250,231
31	48.56	—0.06	227,722	66.6	92	− 3,443	5.551	1,263,992	8,000	1,271,992
Apr. 2	48.41	−0.15	230,119	67.3	89	+ 1,884	5.790	1,332,330	7,000	1,339,330
4	48.08	−0.33	226,695	66.3	89	— 4,552	5.364	1,215,970	5,000	1,220,970
7	47.71	−0.37	223,193	65.3	89	— 3,662	5.300	1,183,001	4,000	1,187,001
9	47.78	+0.07	226,274	66.2	89.5	+ 3,321	5.373	1,215,849	4,000	1,219,849
11	47.70	−0.08	233,503	68.3	88	+ 6,955	5.122	1,195,964	3,500	1,199,464
13	47.60	—0.10	241,545	70.6	89	+ 770	5.513	1,331,745	3,000	1,337,445
15	47.55	—0.05	237,359	69.4	91	— 4,015	5.398	1,281,250	3,000	1,284,250

Measurement of crevasses below Arkansas City to be added to river discharge at Wilson's Point, Louisiana.

[Method used: Surface floats.]

Description of crevasses.	Locality on inch to mile map.	Bank.	Width.	Area.	Mean velocity.	Discharge, cubic feet per second.	Date of observation.	Date of crevasse.
			Feet.	*Sq. feet.*			1890.	
Offutt's*	444.5	L. B.	860	37,467	—0.37	—13,692	Apr. 15	
Lunat	467	R. B.	425	2,975	10.4	30,940	Mar. 19	Mar. 18
Do	467	R. B.	550	3,850	8.0	30,800	Mar. 22	Mar. 18 7 a. m.
Do	467	R. B.	625	4,062	7.2	29.246	Mar. 25	Do.
Do	467	R. B.	630	4,095	7.2	29,484	Mar. 26	Do.
Do	467	R. B.	730	4,380	6.0	26,280	Apr. 1	Do.
Do	467	R. B.	750	4,125	6.0	24,744	Apr. 4	Do.
Do	467	R. B.	760	4,180	5.6	23,408	Apr. 5	Do.
Do	467	R. B.	760	3,800	4.8	18,240	Apr. 8	Do.
Do	467	R. B.	760	3,800	5.2	19,760	Apr. 7	Do.
Do	467	R. B.	765	3,825	4.8	18,360	Apr. 9	Do.
Do	467	R. B.	765	3,825	4.4	16,829	Apr. 10	Do.
Do	467	R. B.	770	3,850	4.4	16,940	Apr. 11	Do.
Do	467	R. B.	770	3,850	4.0	15,400	Apr. 12	Do.
Do	467	R. B.	775	3,875	3.5	13,640	Apr. 14	Do.
Do	467	R. B.	775	3,720	3.4	12,499	Apr. 15	Do.
Point Chicot	472	R. B.	2,940	6,615	0.92	6,055	Mar. 12	Mar. 7

* Maximum discharge March 21, 35,000 cubic feet flowing into river after April 1.
† Measured by A. F. Kilpatrick. Maximum discharge March 19, 31,000 cubic feet.

Crevasse measurements in vicinity of Arkansas City, Arkansas, 1890.

Description of crevasse.	Locality on inch to mile map.	Discharge section.	Width.	Area.	Mean velocity feet per second.	Discharge cubic feet per second.	Date of observation.	Method used.	Date of crevasse.	Remarks.
			Feet.	*Sq. feet.*			1890.			
Brooks' Field Opossum Fork Levee.	.....	R. B.	590	6,404	4.00	25,622	Apr. 19	Surface floats ..	Mar. 27	Maximum discharge Apr. 3, 38,000 cubic feet.
Boggy Bayou	426	R. B.	273	10,860	2.44	26,489	Apr. 19	....do	Apr. 5	Maximum discharge Apr. 3, 44,000 cubic feet.
Sappington	429	R. B.	620	5,118	3.80	18,321	Apr. 17	....do	Mar. 9	Maximum discharge Mar. 12, 35,000 cubic feet.
Ferguson	426	R. B.	320	3,468	4.03	13,987	Apr. 17	....do	Mar. 27	Maximum discharge Mar. 31, 17,000 cubic feet.
Chicot	431.5	R. B.	240	1,700	4.85	8,241	Apr. 11	....do	Mar. 27	Maximum discharge Mar. 27, 10,000 cubic feet.
Between Chicot and Arkansas City	433	R. B.	354	2,480	5.84	14,483	Mar. 25	....do	Mar. 24	Maximum discharge Mar. 26, 17,000 cubic feet.
Do	433	R. B.	390	3,046	0.95	— 2,901	Apr. 17	....do	Mar. 24	Commenced flowing into river Mar. 28.
Drainage openings and crevasses between Arkansas City and Trippe, Ark.	.....	R. B.	16,180	111,013	1.24	137,500	Apr. 7 Apr. 8	....do	.....	Maximum discharge Apr. 10, 248,600 cubic feet.
Do	.....	R. B.	16,190	111,266	1.33	148,591	Apr. 9 Apr. 10	....do	.....	Do.
Do	.....	R. B.	15,000	106,162	1.32	140,558	Apr. 14 Apr. 16	....do	.....	Do.
Catfish Point	432	L. B.	1,718	36,257	5.73	207,851	Apr. 6	Meter	Apr. 4	Maximum discharge Apr. 6, 208,000 cubic feet.
Do	432	L. B.	1,969	43,281	4.72	204,500	Apr. 11	....do	Apr. 4	
Do	432	L. B.	1,969	43,011	4.72	203,173	Apr. 13	....do	Apr. 4	
Lower side of Catfish	431	L. B.	3,097	51,980	2.09	—108,647	Apr. 11 Apr. 13	Surface floats...	Apr. 4 Apr. 5	Flowing into river—maximum discharge Apr. 21, 114,000 cubic feet.
Do	432	L. B.	3,428	54,632	2.09	—114,000	Apr. 11	....do	Apr. 4	
							Apr. 13	....do	Apr. 5	
Easton	435.2	L. B.	750	41,000	1.35	52,296	Apr. 4	....do	Mar. 28	Maximum discharge Apr. 13, 68,000 cubic feet.
Do	435.2	L. B.	776	41,000	1.43	58,752	Apr. 11	....do	Mar. 28	Area of section sounded below crevasse, 29,739 feet—area of section above, 21,581 feet.
Do	435.2	L. B.	780	41,000	1.65	67,650	Apr. 13	....do	Mar. 28	Do.
Huntington	438.5	L. B.	625	24,789	4.46	110,513	Apr. 10	Meter.	Mar. 28	Maximum discharge Apr. 1, 125,000 cubic feet.
Do	438.5	L. B.	625	23,099	4.31	99,513	Apr. 11	....do	Mar. 28	Commenced flowing into river, Apr. 1.
Do	438.5	L. B.	625	21,376	4.36	93,244	Apr. 13	....do	Mar. 28	
Offutt's	444.5	L. B.	860	37,467	—0.37	—13,692	Apr. 15	Surface floats...	Mar. 18	Maximum discharge Mar 21, 35,000 cubic feet.
Columbia and Point Chicot ..	470	R. B..	5,600	25,725	1.28	33,034	Mar. 31	....do	Mar. 28, 4 a. m.	
Do	470	R. B..	5,850	26,905	1.31	35,214	Apr. 3	....do	.....	
Do	470	R. B..	5,850	27,655	1.24	34,402	Apr. 4	....do	.....	Maximum discharge Apr. 3, 35,200 cubic feet.
Do	470	R. B..	5,850	26,480	1.21	31,984	Apr. 5	....do	.....	
Do	470	R. B..	5,850	26,130	1.27	33,144	Apr. 7	....do	.....	
Do	470	R. B..	5,850	25,710	1.11	28,515	Apr. 11	....do	.....	
Do	470	R. B..	5,850	24,170	1.01	24,464	Apr. 14	....do	.....	
Do	470	R. B..	5,850	25,380	0.98	24,947	Apr. 15	....do	.....	

Crevasse measurements in vicinity of Arkansas City, Arkansas, 1890—Continued.

Description of crevasse.	Locality on inch to mile map.	Discharge section.	Width.	Area.	Mean velocity feet per second.	Discharge cubic feet per second.	Date of observation.	Method used.	Date of crevasse.	Remarks.
			Feet.	*Sq. feet.*			1890.			
Miller's Bend	474	L. B..	300	.....	.....	.....	.....	.....	Apr. 7	Discharging into river, maximum discharge April 15, 10,000 cubic feet (estimated).
Skipwith's	530	L. B..	1,020	34,116	1.89	64,636	Apr. 2	....do	Mar. 26	Measured by Surveyor F. P. Spalding.
Do	530	L. B..	1,020	40,063	2.12	84,886	Apr. 5	Meter	.....	
Do	530	L. B..	1,020	39,839	1.91	76,218	Apr. 9	....do	.....	Maximum discharge Apr. 5, 84,900 cubic feet.
Do	530	L. B..	1,020	40,424	1.96	79,130	Apr. 14	....do	.....	
Do	530	L. B..	1,020	42,075	1.80	75,910	Apr. 17	....do	.....	
Do	530	L. B..	1,020	41,174	1.58	65,191	Apr. 19	....do	.....	
Do	530	L. B..	1,020	42,507	1.70	72,186	Apr. 24	....do	.....	
Do	530	L. B..	1,020	42,210	1.55	65,484	Apr. 28	....do	.....	
Do	530	L. B..	1,020	39,970	1.09	43,378	May 2	....do	.....	
Do	530	L. B..	1,020	38,728	0.97	37,610	May 6	....do	.....	

REPORT OF MR. FRED P. SPALDING, UNITED STATES SURVEYOR, ON DISCHARGE OBSERVATIONS AT WILSON'S POINT, LOUISIANA, AND AT SKIPWITH CREVASSE, MISSISSIPPI, 1890.

Observations for the discharge of the river at Wilson's Point, La., were made, beginning on January 27, 1890, and ending on May 7, 1890, during which time a continuous series of observations was kept up of the main river, and after its occurrence, of the Skipwith Crevasse. The observations were taken from the steam survey-boat *Meter*, which during the observation was held by the pilot as nearly as possible upon a point fixed by the intersection of two ranges marked upon the bank. The section used was the same one upon which the observations of 1888 and 1889 were made.

A "Price" current meter was used, and was lowered from the side of the steamboat by a wire rope to six-tenths of the depth of water at each point; a lead of 225 pounds weight was used to sink the meter to the proper depth, and a guy-wire leading to the bow of the boat, to keep it in place vertically. Readings were taken each minute for five consecutive minutes, and a mean of the readings used in the computations. The meter was rated three times during the continuance of the observations, by being held over the bow of a skiff, which was towed by the men along a base-line on the levee, once near Skipwith's and twice at Wilson's Point.

At the break in Skipwith's Levee, observations were taken from a skiff held in place with the oars; the meter was lowered from the bow of the skiff upon an ordinary lead line, with a 20-pound lead to sink it to the proper position. The registrations were counted for a single minute, commonly repeated as a check upon its accuracy, and, as in the main channel, at six-tenths of the depth of water.

As the section measured was located directly across the break through the deep water resulting from the scour, it was thought advisable to take some observations for the purpose of determining if the flow through the break would be fairly measured by this method; and for this purpose, at various times, velocities were taken at every 5 feet of depth in a vertical line at different points in the section. The result of these observations may be briefly stated as seeming to show a quite steady flow through the break, with an average velocity about eight-tenths of that at the surface, and in general correctly represented by the velocity at five-tenths to six-tenths of the depth.

In accordance with general instructions, copies of the field notes have been sent for computation in the office of the Secretary of the Mississippi River Commission.

A table is herewith presented showing results of the field computations:

Results of discharge observations at Wilson's Point, Louisiana, as shown by field computations.

Date.	Wilson's Point gauge-reading.	Lake Providence gauge-reading.	Wilson's Point, La. (main river). Area channel section, 1,000 square feet.	Velocity on channel section, 5 feet per second.	Through channel section, 1,000 cubic feet.	Over east bank, 1,000 cubic feet.	Total.	Slopes (on Louisiana side). For 2,000 feet above section.	Slopes (on Louisiana side). For 2,500 feet below section.
1890.									
Jan. 28	34.95	.....	148	7.38	1,088	.....	1,088	.00080	.00108
31	36.05	.....	150	6.98	1,050	.....	2,050	.00085	.00116
Feb. 3	36.96	37.15	156	7.51	1,176	.....	1,176	.00075	.00116
4	37.20	37.40	166	7.03	1,164	.....	1,164	.00090	.00108
5	37.42	37.57	159	6.87	1,093	5	1,098	.00085	.00116
6	37.59	37.80	164	6.85	1,120	8	1,128	.00075	.00124
8	38.10	38.30	171	6.85	1,173	16	1,189	.....	.....
10	38.40	38.52	178	6.83	1,214	20	1,234	.00085	.00112
11	38.45	38.57	176	6.70	1,182	23	1,205	.00095	.00108
12	38.44	38.60	174	6.40	1,111	23	1,134	.00095	.00112
13	38.45	38.70	173	6.31	1,092	23	1,115	.00080	.00128
14	38.56	38.70	177	6.36	1,124	25	1,149	.00085	.00120
15	38.56	38.70	175	6.18	1,078	25	1,103	.00060	.00108
17	38.62	38.77	176	6.14	1,078	26	1,104	.00075	.00108
20	38.95	39.00	178	5.98	1,064	28	1,092	.00105	.00108
21	39.00	39.13	180	6.33	1,139	28	1,167	.00075	.00112
22	39.15	39.23	182	6.02	1,098	29	1,127	.00090	.00120
24	39.38	39.42	179	6.22	1,114	30	1,144	.00075	.00120
25	39.44	39.47	181	6.11	1,106	30	1,136	.00075	.00116
26	39.44	39.50	180	5.97	1,076	30	1,106	.00075	.00016
27	39.55	39.57	184	5.91	1,084	31	1,115	.00060	.00112
Mar. 1	39.35	39.40	180	5.80	1,045	30	1,075	.00075	.00112
3	39.40	39.45	184	5.91	1,088	30	1,118	.00090	.00112
4	39.48	39.54	185	5.77	1,067	31	1,098	.00085	.00112

Results of discharge observations at Wilson's Point, Louisiana, etc.—Continued.

Date.	Wilson's Point gauge-reading.	Lake Providence gauge-reading.	Area channel section, 1,000 square feet.	Wilson's Point, La. (main river.)					
				Velocity on channel section, 5 feet per second.	Through channel section, 1,000 cubic feet.	Over east bank, 1,000 cubic feet.	Total.	Slopes (on Louisiana side).	
								For 2,000 feet above section.	For 2,500 feet below section.
1890.									
Mar. 5	39.62	39.64	186	5.94	1,103	33	1,136	.00080	.00112
6	39.70	39.82	191	6.01	1,146	34	1,180	.00075	.00112
7	39.98	40.00	193	5.81	1,122	40	1,162	.00070	.00108
8	40.10	40.19	196	.....	1,143	43	1,186	.00060	.00112
10	40.43	40.45	198	.....	1,183	47	1,230	.00075	.00100
11	40.47	40.50	199	.....	1,241	47	1,288	.00085	.00104
12	40.73	40.75	203	5.62	1,141	50	1,191	.00075	.00100
13	40.85	40.90	204	5.54	1,129	50	1,179	.00070	.00096
14	40.88	40.92	205	5.67	1,165	50	1,215	.00060	.00100
15	40.98	41.05	200	5.87	1,171	50	1,221	.00060	.00100
17	40.90	40.67	200	5.92	1,186	47	1,233	.00060	.00104
18	40.86	40.55	199	6.11	1,219	45	1,264	.00075	.00104
19	40.60	40.40	197	6.06	1,195	38	1,233	.00075	.00104
20	40.47	40.25	200	5.66	1,131	35	1,166	.00075	.00104
21	40.46	40.23	201	5.44	1,092	35	1,127	.00075	.00104

Results of discharge observations, Wilson's Point, Louisiana, as shown by field computations.

Date.	Wilson's Point gauge.	Lake Providence gauge.	Area of channel section, 1,000 square feet.	Wilson's Point, La.				Main river slopes to—		Skipwith's Crevasse.	
				Velocity in channel section, feet per second.	Through channel section, 1,000 cubic feet per second.	Discharge per second.		2,000 feet above section.	2,500 feet below section.	Area of section.	Discharge, cubic feet per second.
						Over east bank.	Total.				
										Sq. feet.	
1890.											
Mar. 24	40.48	40.22	201	5.83	1,173	35	1,208	.00075	.00100	.....	.....
25	40.50	40.25	200	6.08	1,219	35	1,254	.00065	.00100	.....	.....
28	40.22	39.90	199	5.95	1,186	30	1,216	.00065	.00092	.....	.....
31	39.75	39.60	196	5.98	1,174	25	1,199	.00060	.00100	.....	.....
Apr. 2	39.72	39.45	196	5.85	1,148	23	1,171	.00060	.00096	34,116	64,636
3	39.85	39.57	197	6.04	1,187	23	1,210	.....	.00084	.....	.....
4	39.60	39.40	196	5.99	1,175	21.5	1,197	.00085	.00092	.....	.....
5	39.45	39.30	196	5.74	1,124	20	1,144	.00070	.00072	40,063	84,886
7	39.45	39.30	195	5.79	1,127	19	1,146	.00060	.00072	.....	.....
8	39.45	39.30	196	5.70	1,117	18	1,135	.00060	.00072	.....	.....
9	39.45	39.30	196	5.62	1,103	17	1,120	.00060	.00072	39,839	76,218
10	39.40	39.30	192	5.73	1,102	16	1,118	.00060	.00072	.....	.....
11	39.40	39.30	192	5.72	1,098	15	1,113	.00060	.00072	.....	.....
12	39.40	39.30	192	5.91	1,137	15	1,152	.00060	.00072	.....	.....
14	39.40	39.30	193	5.59	1,079	15	1,094	.00060	.00072	40,424	79,130
15	39.30	39.25	196	5.60	1,098	14	1,112	.00060	.00088	.....	.....
17	39.30	39.30	194	5.52	1,072	14	1,086	.00045	.00084	42,095	75,910
18	39.25	39.25	194	5.57	1,081	13	1,094	.00040	.00088	.....	.....
19	39.18	39.27	196	5.52	1,081	12	1,093	.00045	.00088	41,174	65,191
21	39.22	39.35	191	5.71	1,093	12	1,105	.00055	.00080	.....	.....
22	39.21	39.33	192	5.61	1,078	12	1,090	.00050	.00088	.....	.....
24	39.25	39.40	194	5.75	1,116	12	1,128	.00070	.00084	42,507	72,186
25	39.18	39.27	195	5.63	1,096	11	1,107	.00050	.00088	.....	.....
26	38.95	39.05	196	.....	1,091	9	1,100	.00055	.00092	.....	.....
28	38.50	38.70	189	5.48	1,038	5	1,043	.00060	.00080	42,210	65,484
29	38.30	38.52	189	5.43	1,027	0	1,027	.00060	.00100	.....	.....
30	38.18	38.40	186	5.53	1,030	.....	1,030	.00060	.00088	.....	.....
May 2	37.98	38.15	186	5.51	1,023	.....	1,023	.00050	.00088	39,970	43,378
5	37.90	38.00	189	5.38	1,018	.....	1,018	.00050	.00080	.....	.....
6	37.75	38.87	190	5.36	1,017	.....	1,017	.00050	.00100	38,728	37,610
7	37.65	37.85	190	5.17	981	.....	981	.00060	.00092	.....	.....

NOTE.—The observed discharges at Skipwith Crevasse are given in table in report of J. J. Hoopes, assistant engineer.

FINANCIAL STATEMENT.

High-water protection of levees.

Balance May 31, 1889		$20,000.00
Received by transfer from Lake Providence allotment		55,000.00
General service allotment		20,000.00
Maintenance of works, first district		27,250.00
Lake Bolivar allotment		5,000.00
By overpayment of voucher		3.00
		127,253.00
Expenditures apportioned for—		
Administration and office expenses	$1,474.23	
Material for protection	59,533.20	
Subsistence	5,262.98	
Transportation and travel expenses	639.62	
Steamer expenses	11,262.68	
Labor on protection	48,332.86	
		126,505.57
Balance June 30, 1890		747.43

All of which is pledged.

Amount that can be profitably expended in fiscal year ending June 30, 1892 $10,000.00

PROTECTION OF LEVEES—THIRD DISTRICT.

Financial statement.

Balance May 31, 1889		$3,701.57
Expended and apportioned for—		
Administration and inspection	$393.56	
Material for repairs and protection	1,642.23	
Labor for repairs and protection	1,646.00	
Miscellaneous	19.78	
		3,701,57

OBSERVATIONS AND DISCHARGES.

Discharge measurements were made by Assistant Engineer Tollinger at Wilson's Point, in July, 1889. The field computations gave the following discharges:

Date.	Wilson's Point gauge.	Discharge.
1889.	*Feet.*	*Cubic feet.*
July 3	29.20	856,000
July 4	28.87	861,000
July 5	28.30	792,000

Discharge observations, during the flood of 1890, were made at Wilson's Point, La., Arkansas City, Ark., and at the several crevasses. A report on these observations, with tables of results, is given under the heading "High-water protection of levees and the flood of 1890," which see.

OBSERVATIONS AND DISCHARGES, THIRD DISTRICT.

Financial statement.

Balance May 31, 1889		$82.38
Expended for—		
Fuel	$41.50	
Stationery	40,88	
		82.38
Amount that can be profitably expended in fiscal year ending June 30, 1892.		5,000.00

GAUGES, THIRD DISTRICT.

The river gauges in the third district, at Clarendon, Ark., Arkansas City, Ark., Greenville, Miss., and Yazoo City, Miss., have been maintained and read during the year and the weekly gauge reports forwarded to the Secretary of the Commission for computation.

Financial statement.

Balance May 31, 1889		$1,229.65
Expended for—		
Pay of observers	$720.00	
Traveling expenses	10.75	
		730.75
Balance June 30, 1890		498.90
In treasury	300.00	
In hand	198.90	
		498.90
Less liabilities		180.00
Available balance, June 30, 1890		318.90
Amount that can be profitably expended during fiscal year ending June 30, 1892		$1,000.00

LEVEES.

The only work done in levee-building during the year was in enlarging a weak place in the levee south of Lakeport, Ark., 8,419½ cubic yards of earth being here added to the levee. The work was done by Mr. E. Hyner, under verbal agreement, at 18 cents per cubic yard.

LEVEES, TENSAS FRONT IN ARKANSAS.

Financial statement.

Balance May 31, 1889		$2,057.79
Expended and appertioned for—		
Administration and inspection	$488.41	
Repair and enlargement	1,515.51	
Subsistence	15.30	
Miscellaneous	38.57	
		2,057.79
Amount that can be profitably expended in fiscal year ending June 30, 1892		2,000,000.00
For levees Yazoo front:		
Amount that can be profitably expended in fiscal year ending June 30, 1892		1,000,000.00

LEVEES, SECOND MISSISSIPPI DISTRICT.

Financial statement.

Balance May 31, 1889		1,649.32
Expended for—		
Repairs to levees	$113.64	
Transferred to surveys, examinations, and inspections	1,535.68	
		1,649.32

LEVEES, YAZOO FRONT, BEN LOMOND HOOF.

Financial statement.

Balance May 31, 1889		613.78
Transferred to surveys, examinations, and inspections		613.78

SURVEYS, EXAMINATIONS AND INSPECTIONS.

A list of the surveys made during the year previous to May, with a description of the results found, is given in the following report of Mr. Fred Spalding, surveyor.

Two parties were sent out in May, one to Lake Providence Reach, under Mr. William P. Richards, draughtsman, and one to the Greenville Bends, under Mr. Fred Spalding, surveyor, to locate the shore-lines, for comparison with previous surveys.

Maps of Lake Providence Reach and of the Greenville Bends, showing changes in the shore-lines to May, 1890, and of Greenville Harbor are herewith. The survey of Greenville Harbor made in October and November, 1889, showed that the dikes constructed in 1887 were in good condition and that no change had taken place in the shore-line.

Rapid caving is going on at Caulk's Point, at the Greenville Bends, and at several points in Lake Providence Reach.

Cut-offs are more or less threatened at Caulk's Point and at the several Greenville Bends; but no immediate danger from caving exists, except at Ashbrook Point. The distance across the neck from Georgetown Bend to Miller's Bend was, in 1882, 4,000 feet; in July, 1890, 2,700 feet; and in May, 1890, 2,400 feet.

Caving is most rapid during the time the river is falling from a high to a medium stage. As the river is still high, it is probable that very rapid caving will occur during the next few months, and that the distance above given will be considerably reduced by the time revetment work could be begin in the fall.

A cut-off here would prove extremely injurious to the river, to existing improvements below, and to riparian interests. To surely prevent it work should be begun at once, and funds for properly revetting the part of the bank in Georgetown Bend immediately in front of the narrow neck should be allotted from the very next appropriation. If this is not done, the failure of the river and harbor bill for one or two succeeding years may delay the work so long as to permit the threatened cut-off to take place.

The United States should, I think, acquire title to the land comprised in the several necks, so that they can be kept covered with a thick forest growth, to check the current running across the necks in time of high water. As a further protection against cut-offs a high, strong levee should be built along the axis of each neck, to entirely prevent the water from running across it.

REPORT OF MR. FRED. F. SPALDING, SURVEYOR, ON SURVEYS, EXAMINATIONS, AND INSPECTIONS MADE DURING THE YEAR ENDING MAY 31, 1890.

Surveys have been made in the following localities: Lake Bolivar Front, Caulk's Point, the Greenville bends, Greenville Harbor, Lake Providence Reach.

LAKE BOLIVAR FRONT.

An examination of Lake Bolivar Front was made in June, 1889, with soundings over the revetment work for the purpose of determining the position and condition of the work, a report of which, with map, was at that time submitted.

CAULK'S POINT.

The survey of the river in vicinity of Caulk's Point, Arkansas, was made in June, 1889, for the purpose of showing the changes which have occurred in shore-lines since the survey of 1881–'82, and to determine the probability of a cut-off across the neck. As was shown by the measurement of this neck, given in the last Annual Report, its width has been reduced from 5,800 feet in 1882 to 3,900 feet, with rapid caving still in progress in the most narrow part. Although the ground here is quite low, the neck is so fully covered by thick forest growth that it is not thought any considerable current could exist across it at high water.

The length of caving bank to be protected in the bend above the neck, to prevent the making of the cut-off, is at present above 2½ miles. The survey was not extended above this bend, and no examination of the river has been made to determine the probable permanence of the existing conditions.

The map of this survey, already submitted, gives shore-lines of 1882 and present shore-lines from Wildwood Point to Catfish Point, a distance of about 18 miles, and shows soundings in the bend above the neck and location of the work upon Bolivar Front.

THE GREENVILLE BENDS.

The Greenville bends consist of five contiguous bends, beginning a short distance below Arkansas City, Ark., and extending about 40 miles to a point a few miles below Greenville, Miss. These bends are separated by four narrow necks of land, the cutting through of each of which is, to a greater or less extent, threatened by caving banks above.

In the upper or Ashbrook neck the width since 1882 has been diminished from about 4,000 feet to about 2,700 feet, and present conditions are favorable to a continuation of the caving at a still more rapid rate. The upper bank is of light material, and the current in the bend above strong and close against it.

The locality of rapid caving extends at present for some distance above the narrow part of the neck, and as the caving in the bend above Offutt's Landing tends to throw it lower in Georgetown Bend, it will continue to strike the weak point with increasing force. The caving bank requiring protection begins at Offutt's Landing and extends about 4 miles around Georgetown Bend.

In Rowdy Bend the caving bank begins at Gaines's Landing and extends about 4 miles down the bend. Below this point some caving occurs, but to a minor degree.

The least width of the Panther Forest Neck is 8,000 feet, and the caving since 1882 amounts to about 1,000 feet. The large Panther Forest levee, however, is within about 1,000 feet of the bank at the point of most rapid caving, and will soon be placed in danger.

In Miller's Bend the caving is slight, especially in the vicinity of Tarpley Neck, which is about 4,100 feet wide. The land is high and under cultivation.

The Leland Neck is high ground and under cultivation, but little caving is taking place in the bend above, in vicinity of the Neck, although at a point higher up, between Linwood and Pastoria Landing, it is considerable.

Maps have been already submitted of this survey, showing on small scale (1 : 300,000) the shore bar and levee lines of the entire reach, and on larger scale (1 : 10,000) separate sheets giving soundings in the three upper bends. A map will also be submitted with this report showing changes in shore-lines to the present month.

As the water is still at a high stage, it is proper to notice that this map will not represent the full effect of the present high-water season, which will be greatest during the time of falling to medium stage.

GREENVILLE HARBOR.

A survey of Greenville Harbor was made in October and November, 1889, to show the condition of the dikes and their effect upon the channel depths. A map of this survey was at that time submitted.

LAKE PROVIDENCE REACH.

Caving has continued on the head of Sarah's Island and in the lower part of Louisiana Bend. Heavy caving has taken place on the front of Island 92. A considerable portion of the upper part of Skipwith's Tow-head has washed away.

At Wilson's Point the caving is less rapid than formerly, and at Mayersville it is lower down, with a tendency of the main channel to take the west side of the middle bar.

At and below Longwood, La., heavy caving continues, as also on the Mississippi side near Shipland Landing. The main channel has been transferred from the Louisiana shore to outside the middle bar below Dessona Landing. A map will be presented with this report showing changes in shore-line to the present month.

Soundings over the newly completed work in Louisiana Bend were made in December, 1889, for the purpose of comparison with like soundings to be taken after the present high water has subsided.

The surveys made in May, 1890, show recent changes of shore-line at Lake Providence Reach and in the Greenville bends. Maps of these surveys are herewith submitted; they show in general a continuation of the conditions already stated.

LAKE PROVIDENCE REACH.

On the point at head of Sarah's Island the width of caving since the survey of May 1889, is about 1,200 feet, causing the current to strike the banks correspondingly lower in Louisiana Bend, and changing to some extent the location of caving.

The caving in Louisiana Bend during the last year has been mainly below the landing at Pilcher's, in and below the head of Old River; it extends lower than is shown by other recent surveys, and is heaviest near the lower end, reaching a maxi-

mum width of about 1,000 feet and averaging about 600 feet for a distance of 2½ miles below the end of the revetment works.

As the caving still continues rapidly on Sarah's Island, it is evident that caving in the bend will go lower, and make it necessary that the revetment be carried throughout the bend to a point at least 3 miles below the end of the present work. On Island 92 the width of caving is about 300 feet, and extends a distance of 1½ miles.

A piece of Skipwith's Tow-head about 1,500 feet wide has been cut off; at Mayersville and below the caving averages about 200 feet wide for a distance of 2 miles.

A small caving is shown just below Homochitta Landing, due no doubt to the change, already noted, of the main channel to the west side of the bar opposite Mayersville, and showing the tendency to a shifting of the scene of caving from the vicinity of Mayersville to the bank just above and at the head of the baleshed dikes.

From Longwood to near Lake Providence the caving during the year ranges from about 300 to 600 feet in width for a distance of 4 miles, and at Shipland Point it is about 500 feet wide and 1 mile in length.

THE GREENVILLE BENDS.

In Georgetown Bend the maximum caving is shown to be in the narrow part of the Ashbrook Neck, which has decreased in width by over 300 feet since the survey in July, 1889, leaving an effective width of about 2,400 feet. The extent of caving is, as stated, about 4 miles.

In Rowdy Bend the principal caving reaches an average width of about 200 feet, and the distance to the Panther Forest Levee from the edge of the bank has decreased to about 800 feet.

At the time of making the survey in Rowdy and Georgetown bends the water was still near the top of bank in the concave portions, the process of caving was in full operation, and it seems probable that the new lines given do not by any means represent their probable position at the next low-water season.

In Miller's Bend the caving for the season is more than was anticipated at and below the Tarpley Neck, having reached an average of about 200 feet in width and reduced the width of the neck to 4,000 feet. In the upper part of the bend the caving is slight.

There has been no considerable caving in Spanish Moss Bend during the season, except at the lower end, at Point Chicot, where for a distance of 2 miles it has an average width of about 400 feet.

In Bachelor's Bend the head of caving is somewhat lower than formerly, on account of the rapid caving at Point Chicot. It begins about 1 mile above Barnes's Landing and extends to the protection work at Greenville, a distance of 2½ miles, with an average width of 300 feet.

No caving has taken place in vicinity of the dikes in front of the town; above them, however, and below those more recently placed, as well as between the two upper dikes, the bank has caved in pockets.

The caving from above has also gone behind the upper mattress and taken the bank from under it.

Indications at present are that unless the work be extended above to protect the upper part of the bend caving from that direction will get behind and undercut the work now in place.

FINANCIAL STATEMENT.

Surveys, examinations, and inspections.

Balance May 31, 1889		$2,685.76
Received by transfer from levees Yazoo Front, Ben Lomond Hoop		613.78
Received by transfer from levees second Mississippi district		1,535.68
Received by transfer from Lake Bolivar Front		3,000.00
Total		7,835.22
Expenses apportioned for:		
Administration and inspection	$3,966.35	
Steamer expenses	3,231.01	
Subsistence	500.22	
Miscellaneous	75.38	
		7.772.96
Balance on hand June 30, 1890 (all of which is pledged)		62.26
Amount that can be profitably expended in fiscal year ending June 30, 1892		10,000.00

During the year ending May 31, 1890, there have been no new transportation lines established, nor any addition to the tonnage of any of the cities contained in this district.

Maps, lists of civilian engineers employed on work of river and harbor improvement, third district, and list of plant belonging to the United States, and used upon Mississippi River, third district, with its approximate value, May 31, 1890, accompany this report.

Very respectfully, your obedient servant,

W. YOUNG,
Captain of Engineers.

Col. C. B. COMSTOCK,
Corps of Engineers, Bvt. Brig. Gen., U. S. A.,
President Mississippi River Commission.

Approximate value of plant belonging to the United States and used upon the Mississippi River, third district, May 31, 1890.

Class of property.	No.	Approximate value, May 31, 1890.	Class of property.	No.	Approximate value, May 31, 1890.
Steam-boat *Emma Etheridge*	1	$13,500	Machine shop (with outfit)	1	$3,000
Steam-boat *Osceola*	1	10,800	Carpenter shop (with outfit)	1	600
Steam-boat *Vidalia*	1	9,400	Pile-drivers and machinery	16	16,000
Steam-boat *Meter*	1	4,000	Small scow	1	20
Steam-tug *Parker*	1	6,000	Yawls	7	210
Mattress-boats	5	7,500	Skiffs	42	630
Quarter-boats	1	2,000	Tools and appliances	....	1,000
Quarter-boats (with outfit)	10	10,000	Office furniture, safe, etc	....	300
Quarter-boats (with outfit)	3	1,500	Menge dredge	1	30,000
Hydraulic graders	2	24,000	Dump scows	2	10,000
Barges (square decked)	33	22,100	Surveying instruments	....	2,000
Barges (square decked)	6	1,800			
Barges (model)	10	16,000	Total		192,360.00

List of civilian engineers employed on work of river and harbor improvement in charge of Capt. William T. Rossell, Capt. S. S. Leach, and Capt. W. Young, Corps of Engineers, from May 31, 1889, *to May* 31, 1890 (*inclusive*), *under the river and harbor appropriation act approved August* 11, 1888.

Name and residence.	Time employed.	Compensation per month.	Where employed.	Work on which employed.
	M. *D.*			
Arthur Hider, Louisville, Ky.	7	$200	Ashton, La	Revetment of Louisiana Bend.
	2	200	Greenville, Miss.	Charge of repairs to plant and care of property.
	2	200	Greenville, Miss.	Protection of levees during high water.
H. St. L. Coppée, Vicksburg, Miss.	2 5	175	Ashton, La	Revetment of Louisiana Bend.
	2 22	175	Greenville, Miss.	Building dikes in Greenville Harbor.
	1	175	Bolivar, Miss	Repairing revetment Lake Bolivar Front.
	6 3	175	Vicksburg, Miss.	Repairing dam and dike in Vicksburg Harbor. Charge of dredging.
E. C. Tollinger, Wrightsdale, Pa.	7	160	Ashton, La	Revetment of Lonisiana Bend.
	2	160	Greenville, Miss.	Repairs to plant and charge of property.
	3	160	Arkansas City, Ark.	Protection of levees during high water.
Henry Goodrich, Lake Providence, La.	1 16	175	Ashton, La	Levees Tensas Front.
	2 22	175	Grand Lake, Ark.	Do.
	2 8	175	Raleigh, La	Protection of levees during high water.
John J. Hoopes, Arkansas City, Ark.	2	150	Arkansas City, Ark.	Discharge observations.

MISSISSIPPI RIVER COMMISSION

I.M.R. LAKE PROVIDENCE, LA

Capt. Willard Young, Corps of Engrs. U.S.A.
in charge

CHART OF
LAKE PROVIDENCE REACH

Showing changes in shore line and
condition of Improvements

May, 1890

Fred. P. Spalding, U.S. Surveyor

Legend

------ *Represents Shore Line of Oct. 1881*
..... " " " *May, 1889*
" *Bank Protection of 1889*
" *Intact Dikes*
" *Top broken Dikes*

To accompany Annual Report, May 31, 1890

Capt of Engrs

ARKANSAS

LOUISIANA

ISLAND No. 92

SARAH'S ISLAND

LOUISIANA BEND

Pilcher's Pt Ldg

Old River

Mouth of Old River

Skipwith's

SKIPWITH

Wilson's Pt Ldg

WILSON'S POINT

MOON LAKE

Mayersville

COTTONWOOD

WOODLAND

VISTA

HOMOCHITTA

LONGWOOD

HOLLY RIDGE

OAKLEY

HOPEWELL

ELTON

RESERVE

ALL RIGHT

STACK ID.

ELLISLIE

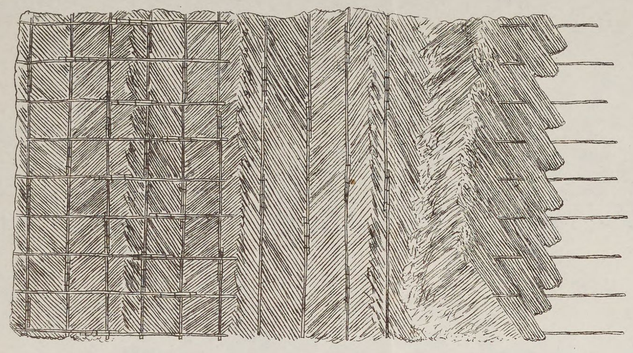
LAKE PROVIDENCE

BEN LOMOND

SHIPLAND

DEESONA

4000 3000 2000 1000 0 1000 Meters
18000 15000 12000 9000 6000 3000 0 Feet
3 2 1 0 ¼ ½ ¾ 1 Miles



Plan of Mats

Scale enlarged 12½ times

MISSISSIPPI RIVER COMMISSION

THIRD DISTRICT

MAP
of the
LOUISIANA BEND REVETMENT

Work done under the Direction of

CAPT. WM. T. ROSSELL, CORPS OF ENG'RS, U.S.A.

JUNE - DECEMBER, 1889

Scale in Feet

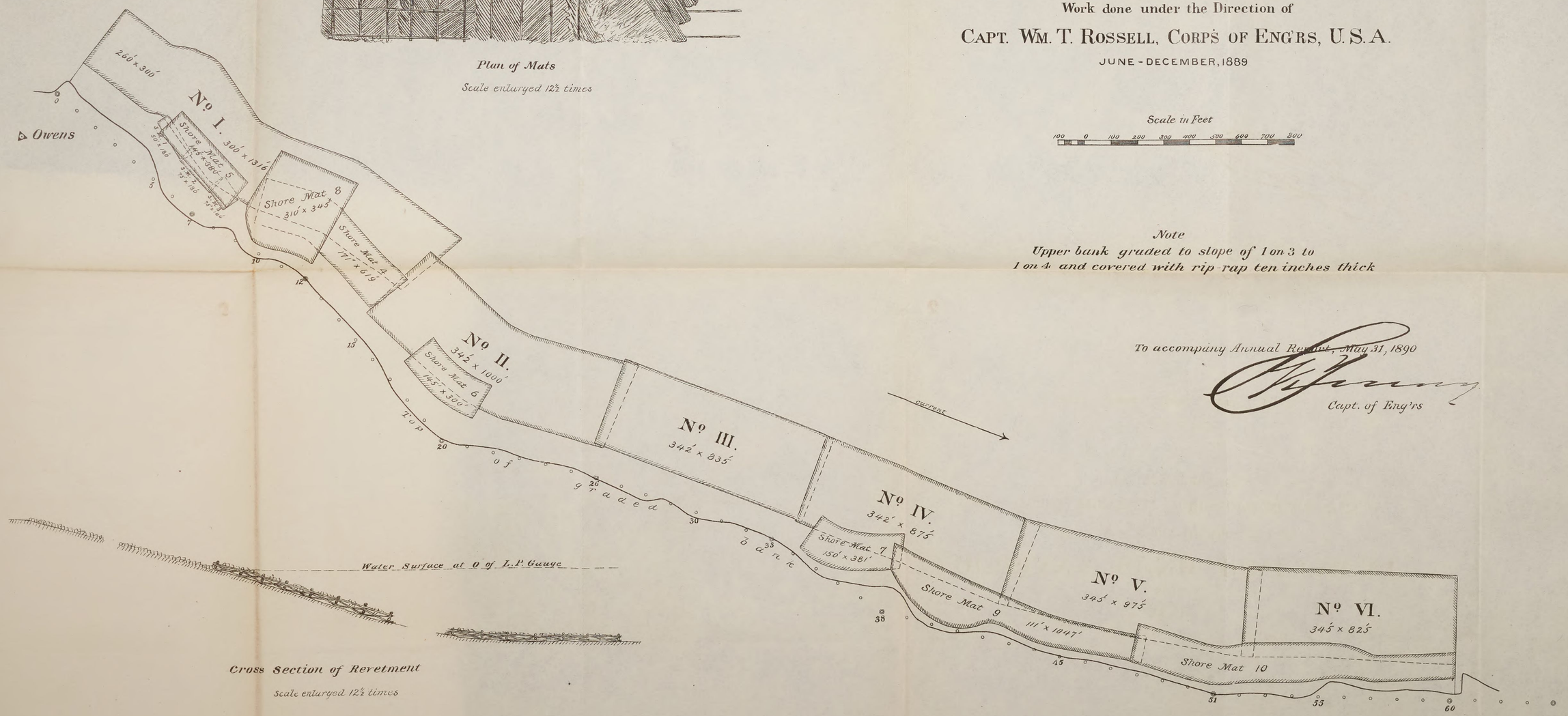
100 0 100 200 300 400 500 600 700 800

Note

Upper bank graded to slope of 1 on 3 to 1 on 4 and covered with rip-rap ten inches thick

To accompany Annual Report, May 31, 1890

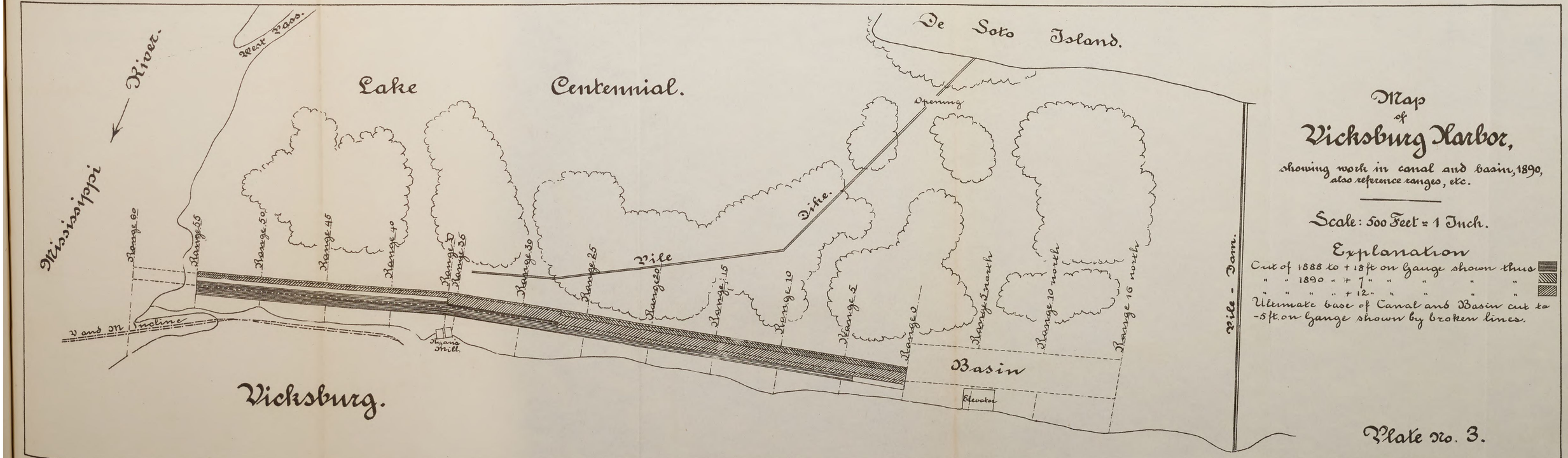
Capt. of Eng'rs



Cross Section of Revetment

Scale enlarged 12½ times

SMARTS



Map of Vicksburg Harbor,

showing work in canal and basin, 1890, also reference ranges, etc.

Scale: 500 Feet = 1 Inch.

Explanation

Cut of 1888 to +18 ft on Gauge shown thus
" " 1890 " +7" " " " "
" " " " +12" " " " "
Ultimate base of Canal and Basin cut to -5 ft. on Gauge shown by broken lines.

Plate No. 3.

Survey of GREENVILLE HARBOR

Made under the Direction of

Capt. Wm. T. Rossell, Corps of Eng'rs, U.S.A.

Oct. and Nov. 1889

To accompany Annual Report, May 31, 1890.

Capt. of Eng'rs.

Scale

100 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 Feet

Arthur Hiden Asst Engr



Note

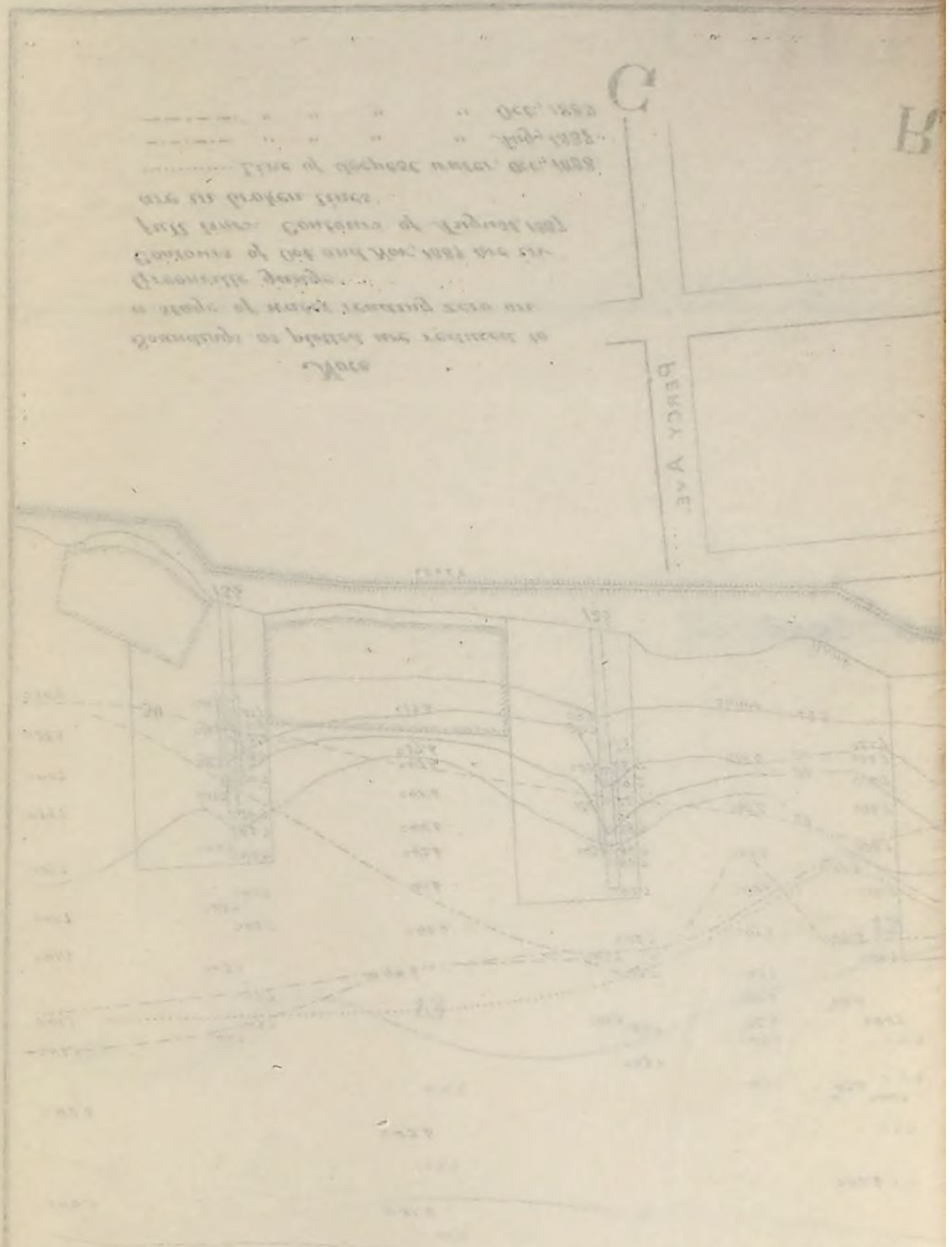
Soundings as plotted are reduced to a stage of water reading zero on Greenville gauge.

Contours of Oct. and Nov. 1889 are in full lines. Contours of August, 1887 are in broken lines

..... *Line of deepest water, Oct., 1889*

-.-.-. " " " " *Aug., 1887*

---.--- " " " " *Oct., 1889*


C
K
AVE. YORK

COMPARATIVE SECTIONS
IN
GREENVILLE HARBOR, MISS.

OCTOBER, 1889.

Scale

20 0 20 40 60 80 100 120 140 160 180 Feet

Note

Sections of Dikes as sunk, 1887 & 1888, are shown in broken lines

Sections of Dikes as determined by soundings of October, 1889 are shown in full lines

..... Represents surface of water at 0 of G. gauge

-.-.-.- " sections 50ft. below dikes (Oct '89)

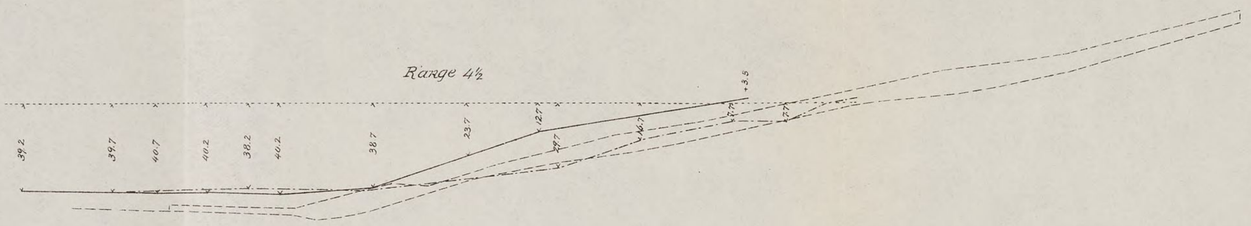
Water surface, +3.3 on Greenville gauge during sounding

Arthur Hiden
Asst Engr.

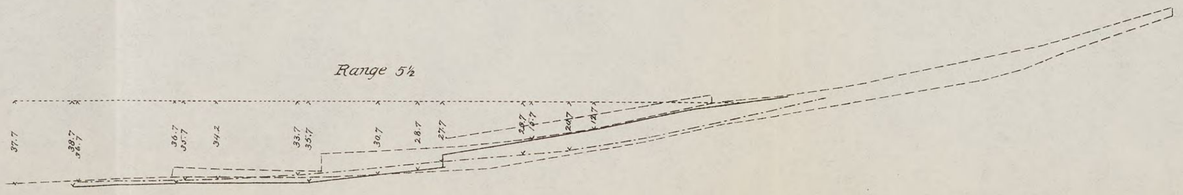
To accompany Annual Report, May 31, 1890

C. Suter
Capt. of Eng'rs.

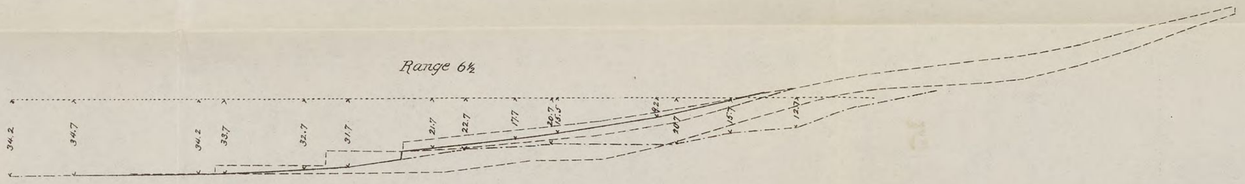
Range 4½



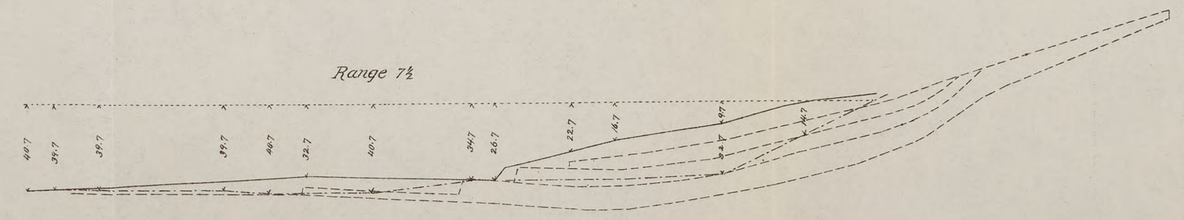
Range 5½



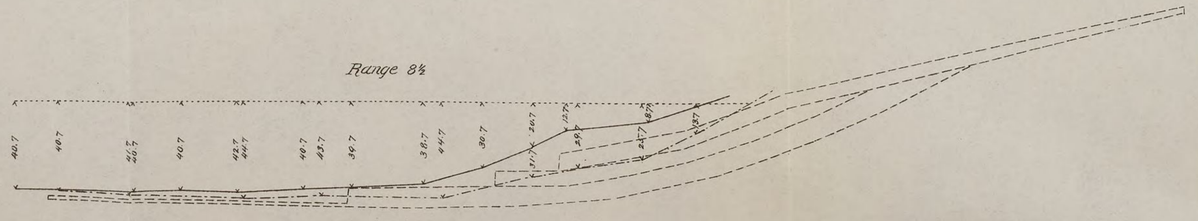
Range 6½



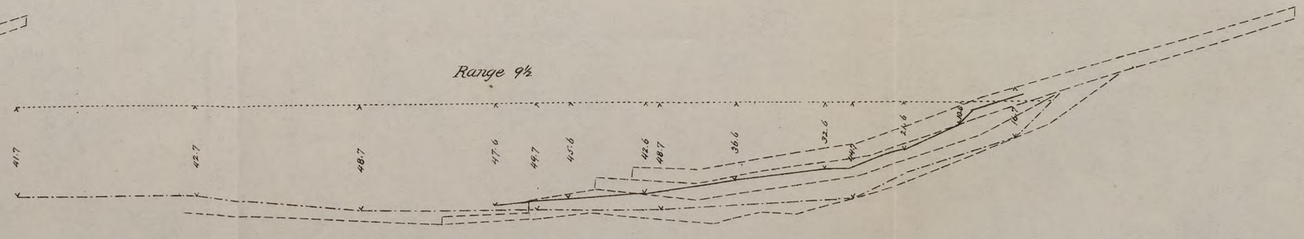
Range 7½



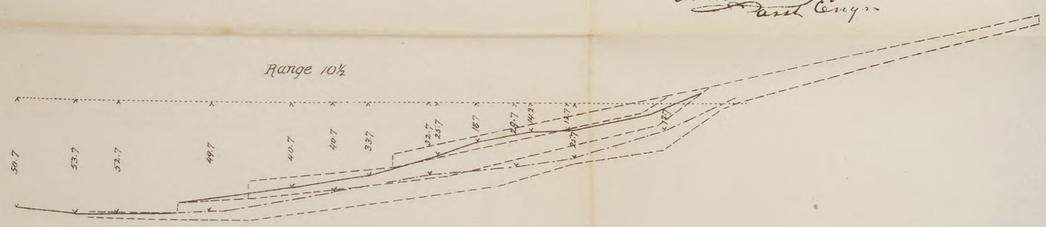
Range 8½



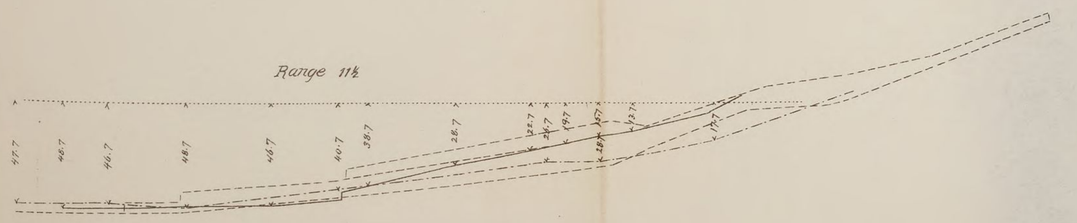
Range 9½



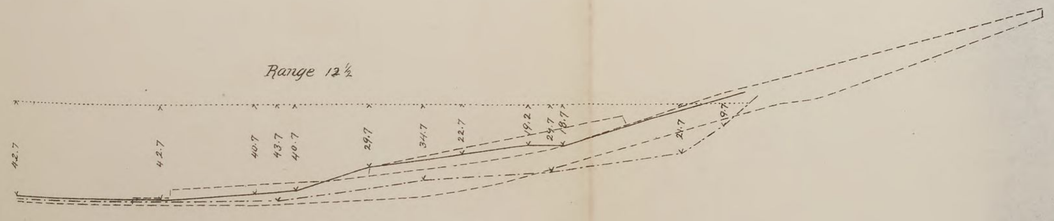
Range 10½



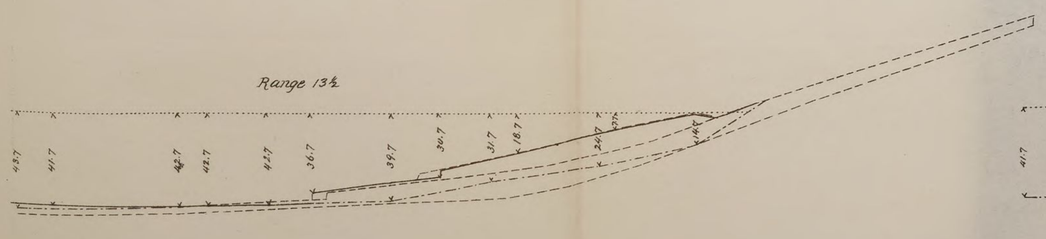
Range 11½



Range 12½



Range 13½



COMPARATIVE

IN

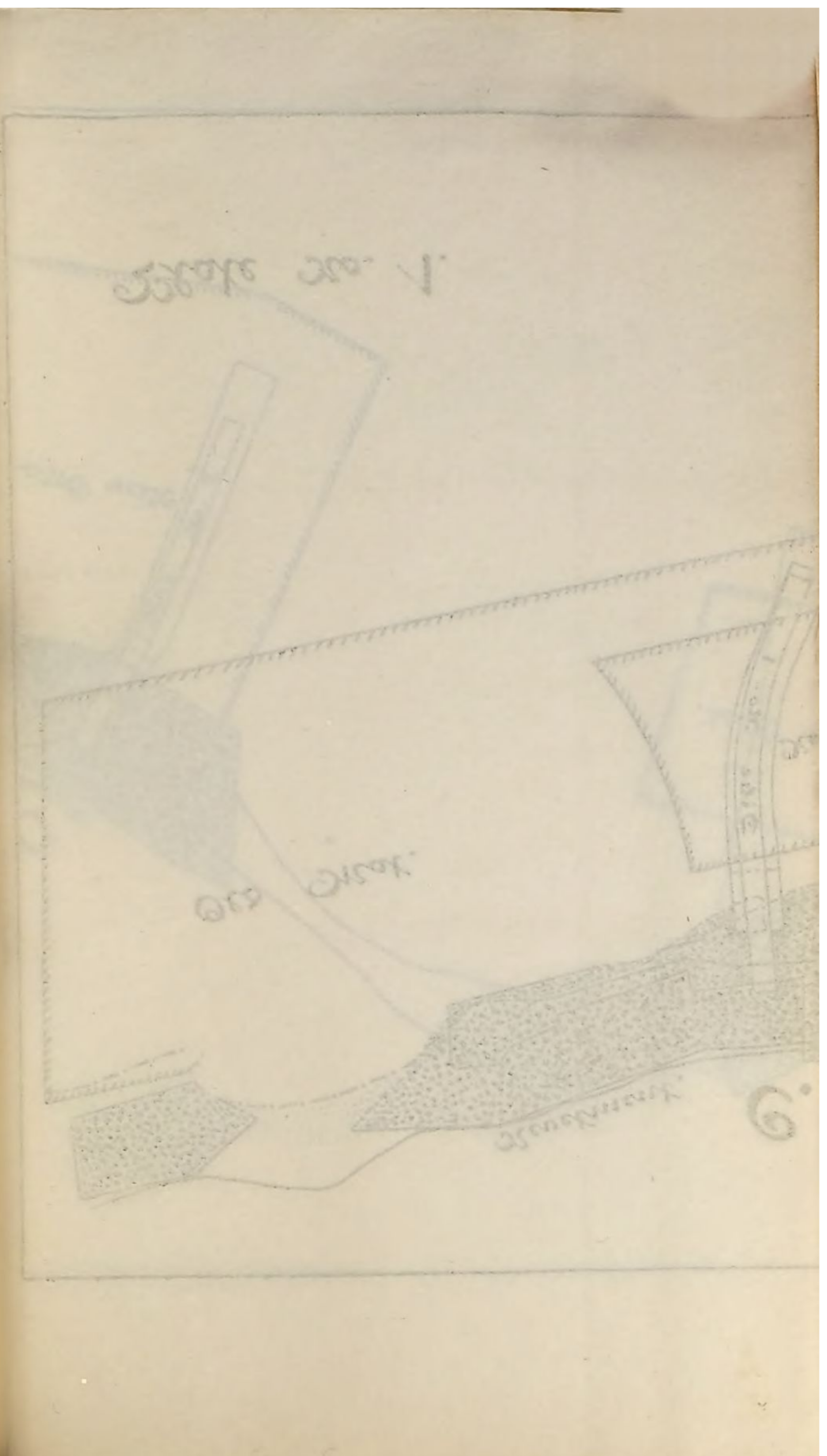
GREENWICH HAL

OCTOBER

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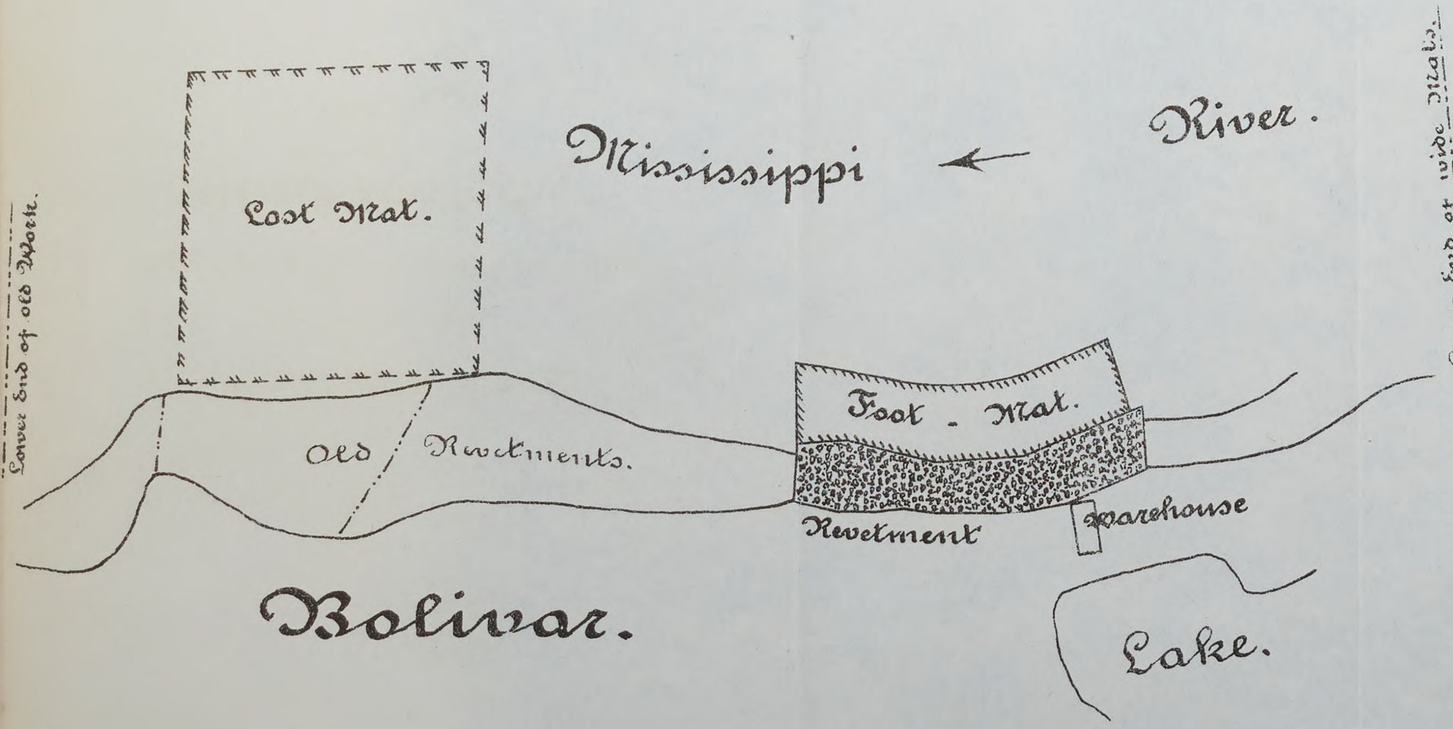


Map of Bolivar Front,

showing repair work of 1889.

Scale: 120 Feet = 1 Inch.

Plate No. 2.



MAP OF
a portion of
THE MISSISSIPPI VALLEY
showing area overflowed
1890

Scale of Miles

To accompany Annual Report, May 30, 1890
W. H. Bixby.
Capt of Engrs.

Note

The boundary of the part overflowed is shown by a dotted line shaded towards the high ground. Shaded portions shown within this area were not flooded. The flood limits were obtained from a reconnoissance made during the overflow.

Arthur Hider
Asst Engr.

Eng 90

NORTH
WEST
EAST
SOUTH

PLATE 3.

To accompany Annual Report May 31. 1890

H. G. Gunn

Capt. of Engr's

DISCHARGE AT ARKANSAS CITY.

		Thousands of cub. ft per sec. Discharge in River Channel	Discharge of Crevasses.	Discharge Arm of Bayou.	Total. Discharge cub. ft per second including Crevasses
Mar. 1890	14	1,186	34	30	1,250,000
"	19	1,418	44	30	1,492,000
"	25	1,220	66	30	1,316,000
"	26	1,228	63	30	1,321,000
"	28	1,223	58	30	1,311,000
"	30	1,250	136	30	1,415,000
"	31	1,272	191	30	1,493,000
Apr	2	1,339	243	30	1,612,000
"	4	1,221	261	30	1,512,000
"	7	1,187	431	30	1,648,000
"	9	1,220	414	26	1,660,000
"	11	1,199	365	32	1,596,000
"	13	1,335	349	37	1,721,000
"	15	1,283	235	41	1,559,000

Arthur Hider
Asst. Engr.

CREVASSE MEASUREMENTS.
— IN —
— Vicinity of Arkansas City —

Catfish Point.
Ark. City & Trapp's
Huntington
Eastons
Brooks field
Boggy Bayou
Ferguson's
Chicot
offlets
Lower S. end of Catfish Point
Discharge of Crevasses
+200000. C. Ft
+150000. C. Ft
+100000. C. Ft
+50000 C. Ft
-50000 C. Ft
-100000 C. Ft
1,700000. C. Ft.
1,600000. C. Ft.
1,500000 C. Ft.
1,400000. C. Ft.
1,300000. C. Ft
1,200000. C. Ft
Including Crevasses
Curve

RIVER DISCHARGE.

Arkansas City Discharge
Mean Discharge between Ark. City and Greenville (60 miles below).
Difference of slope between Ark. City and Greenville (60 miles below).
Difference of slope between Ark. City and Rosedale (40 miles above).
Arkansas City
Rosedale
Greenville
Stone
Waterways
Ark. City
Mean Velocity
6. Ft Per Sec.
5. Ft Per Sec.
49 Ft.
48 Ft.
47 Ft.
46 Ft.
Gauge Curve
March 1
6
11
16
21
26
31
April 5
10
15
20
25
30
May 5.

Eng 90

PLATE 4.

DISCHARGE AT WILSON'S POINT

DISCHARGE OF CREVASSES BETWEEN ARKANSAS CITY AND WILSON'S POINT

+200,000 C.Ft.
+150,000 " "
+100000. C.Ft.
+50000 C.Ft.
-50000 C.Ft.

Skiffwith's
Point Chicot
Lyons
Columbia
Quitman Bend
Offutts

1,300000. C.Ft.
IN
1,200000. C.Ft.
1,100000 C.Ft.

DISCHARGE
RIVER
CHANNEL

7. Ft. per Sec.
6. Ft. per Sec.
6. Ft. per Sec.
5 Ft. per Sec.

Mean Velocity
Mean Velocity
Mean Velocity

Slope 17½ Ft.
17 Ft.
17 Ft.
Slope 11½ Ft.
11 Ft.
11 Ft.
11½ Ft.
11 Ft.

between Greenville and Wilson's Pt. 12 Ft.
between Wilson's Pt. and Duvall's

Gauge Curve
River.
Wilson's Point.

41 Ft
40 Ft.
39 Ft.
38 Ft
37 Ft.
36 Ft
35 Ft

Co. Difference of Slope from Greenville to Wilson's Point (12½ miles above)

Difference of Slope from Wilson's Pt. to Duvall's (8 miles above)
18 Ft.
14 Ft.
10½ Ft.
10 Ft.

Jan 30 | Feb 4 | 9 | 14 | 19 | 24 | Mar 1 | 6 | 11 | 16 | 21 | 26 | 31 | Apr 5 | 10 | 15 | 20 | 25 | 30 | May 5

Raleigh Crevasse. Mar 15.

To accompany Annual Report May 31. 1890

Capt Engr's.

Arthur Nider
Asst Engr.

Eng 90

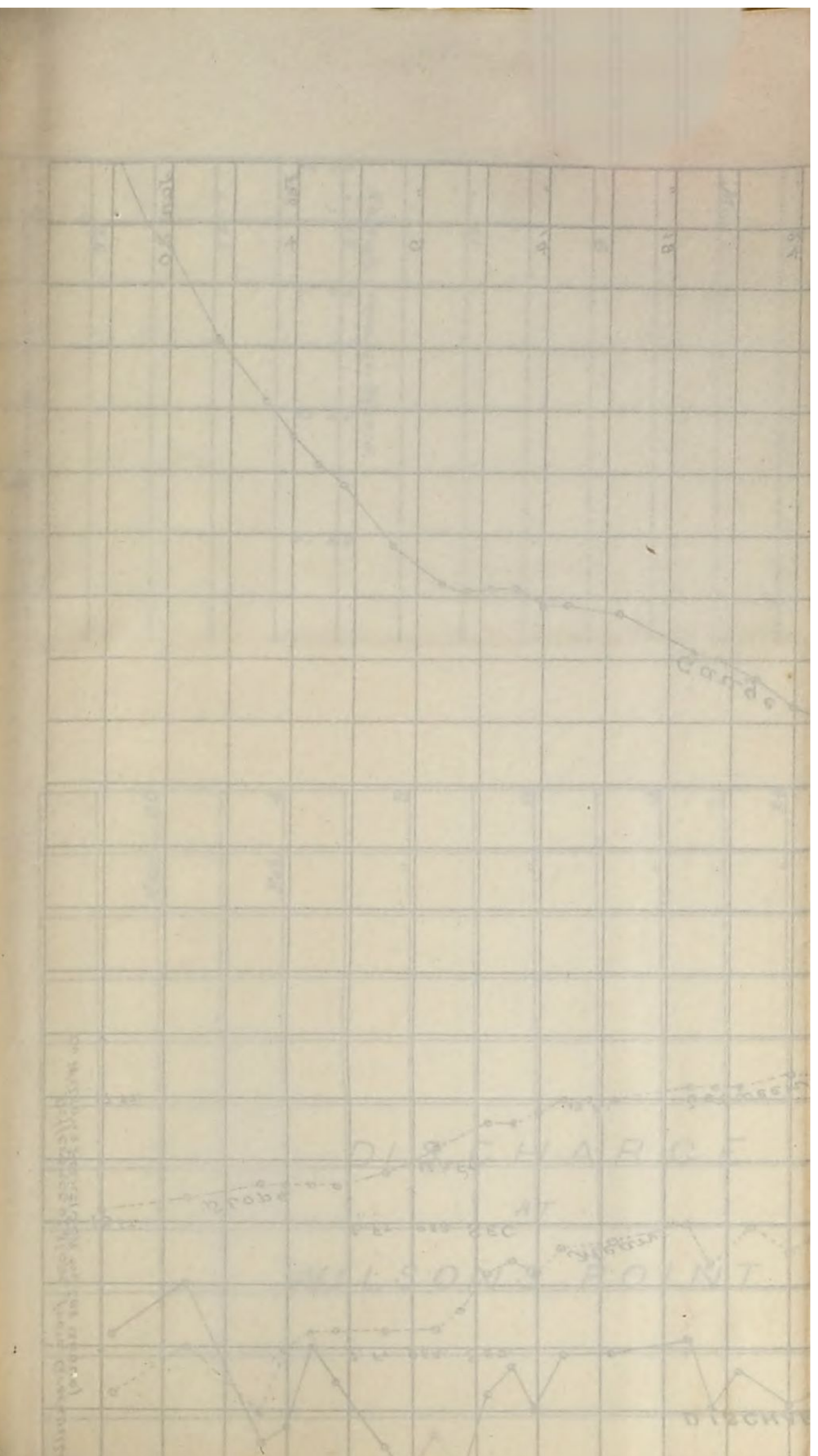
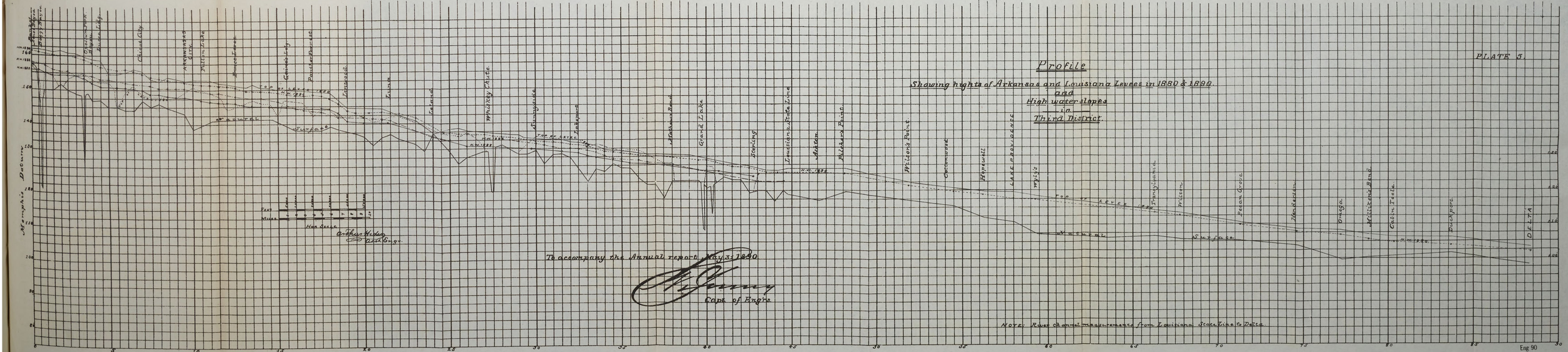


PLATE 5

Profile

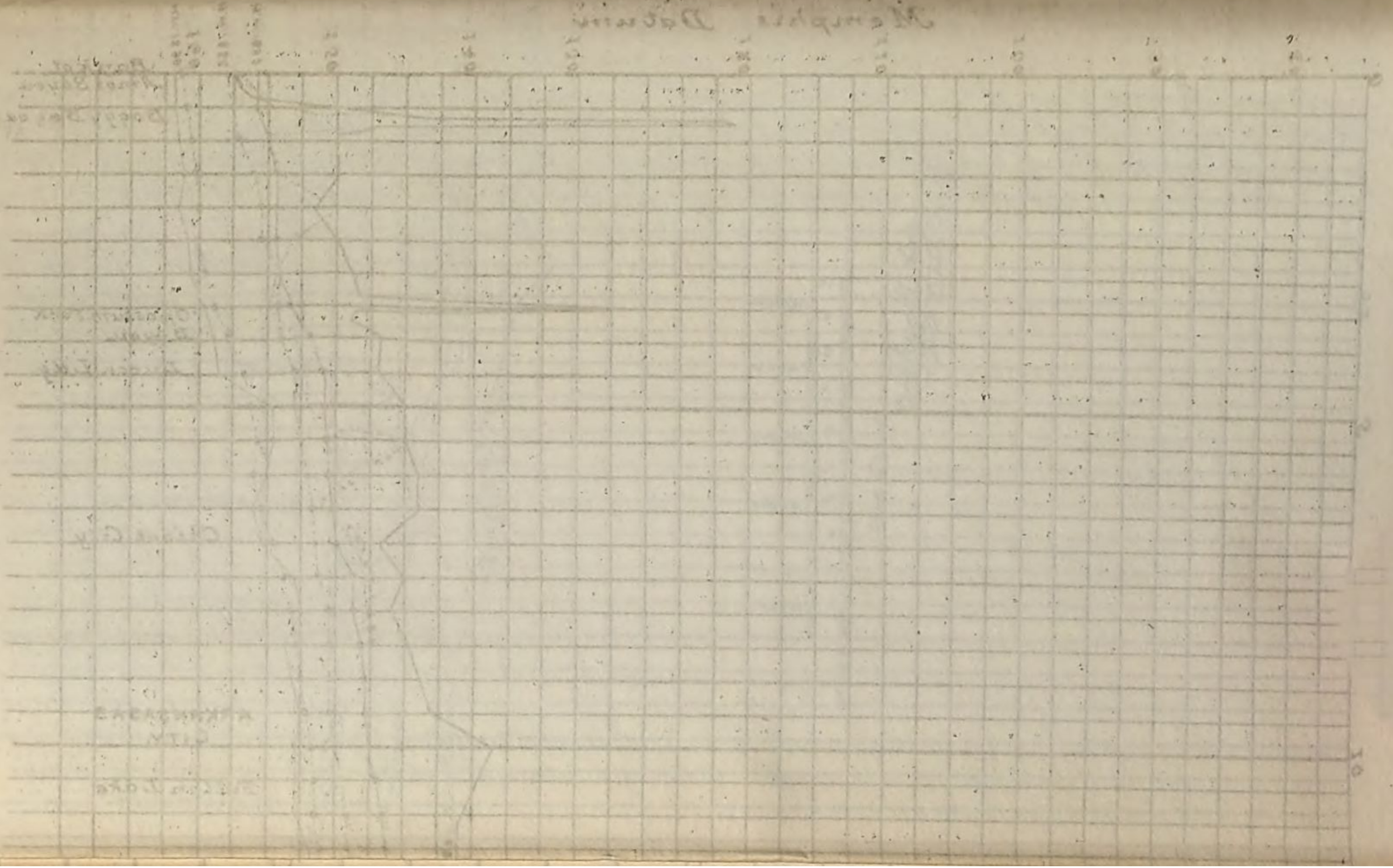
Showing highs of Arkansas and Louisiana Levees in 1880 & 1890 and High water slopes in Third District.

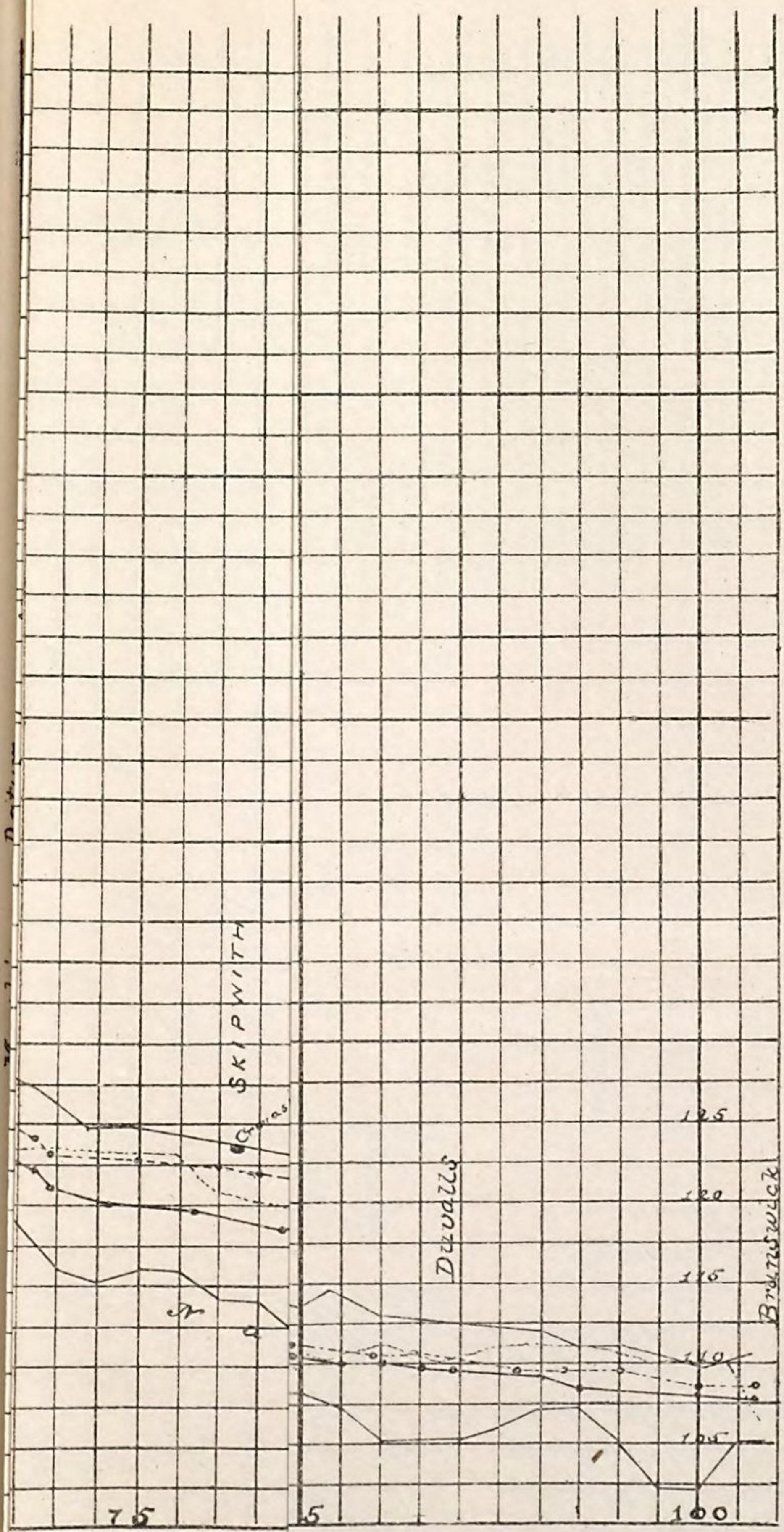


To accompany the Annual report, May 3, 1890

A. Mackey
Capt of Engrs.

NOTE: River Channel measurements from Louisiana State Line to Delta.





Eng 90

I. M. R.

THIRD DISTRICT

CAPT. WM. T. ROSSELL, CORPS OF ENG'RS, U.S.A.

IN CHARGE

HYDROGRAPHIC SURVEY

of

BACHELOR'S BEND

Made in June, 1889

by

Fred. P. Spalding, C.E.

SCALE

1000 500 0 1000 2000 3000 Feet

100 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 Meters

-Legend-

Blank figures show depths and + figures show heights above a stage of water corresponding to zero of Greenville gauge

– – – – Represents bar line at zero of said gauge

..... " shore line in 1881

To accompany Annual Report, May 31, 1890.

Capt. of Eng'rs.

Slough

Mud Bar

Willows

Willows

GREENVILLE

Eng 90

MISSISSIPPI RIVER COMMISSION

THIRD DISTRICT

SURVEY
of the
GREENVILLE BENDS

Made under the Direction of

CAPT. WILLARD YOUNG, CORPS OF ENG'RS, U.S.A.

Fred.P. Spalding, U.S. Surveyor

MAY, 1890

Scale

300 0 300 600 900 1200 1500 1800 2100 2400 2700 3000 3300 Meters

1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 Feet

1 ¾ ½ ¼ 0 1 2 Miles

MISSISSIPPI

ARKANSAS

OFFUTT'S LEG

GEORGETOWN BEND

ISLAND No 81

Offutt's Leg

Gaines Ldg.

ASHBROOK POINT

ROWDY BEND

Swamp

Levee

Levee

PT. COMFORT CUTOFF

ISLAND No 82

MILLER'S BEND

LLEWELLYN PLANTATION

TARPLEY PLANTATION

BACHELORS BEND

Barnes Ldg.

PT. CHICOT

LINWOOD PLANTATION

Linwood Ldg.

WOODSTOCK PLANTATION

Bellevue Ldg.

SHAWMOSA BEND

Luna Crevasse

Pastoria Ldg.

Luna Ldg.

Columbia Ldg.

Columbia Crevasse

CRAIG'S PLANTATION

Leland Ldg.

GREENVILLE

91|15 91|14 91|13 91|12 91|11 91|10 91|09 91|08 91|07 91|06 91|05 91|04

33|32 33|31 33|30 33|29 33|28 33|27 33|26 33|25 33|24 33|23

Note

The survey was made at a stage of water reading 37.0 – 33.0 feet on the Greenville gauge.
Shore line of Aug., 1889 is shown thus .....
Shore line of 1882 - - - - - - - - - -
Levee lines ═══

To accompany Annual Report, May 31, 1890

Capt. of Engrs

Eng 90

I. M. R.

THIRD DISTRICT

CAPT. Wm. T. ROSSELL, CORPS OF ENG'RS, U. S. A.,

IN CHARGE

SURVEY

from

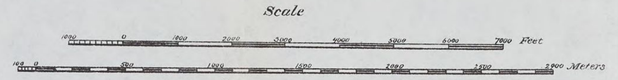
Wildwood Pt. to Catfish Pt.

Made in June, 1889

by

Fred. P. Spalding, C.E.

Scale



To accompany Annual Report, May 31, 1890.

Capt. of Eng'rs.

WILDWOOD POINT

CAULK'S POINT

JERSEY POINT

CATFISH POINT

CATFISH TOWHEAD

Willows and Cottonwood

Willows

Cottonwood

Caving rapidly

Chute

Caving rapidly

Chute

Caving rapidly

Revetment

Note

Water surface at Stormville 159.4 feet above Cairo Datum (Day of sounding)

Broken line represents shore line of 1881

ISLAND 76

Niblett's Ldg.

P.B.M. 76

Melrose Ldg.

Stormville Ldg.

P.B.M. 77

Content Ldg.

Kentucky Ldg.

Buck Ridge Ldg.

Bolivar Ldg.

Ellenton Ldg.

P.B.M. 80

P.B.M. 79

P.B.M. 78

Eng 90

APPENDIX I.

REPORT OF CAPTAIN DAN C. KINGMAN, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FOURTH DISTRICT.

UNITED STATES ENGINEER OFFICE,
New Orleans, June 13, 1890.

COLONEL: I have the honor to transmit herewith my annual report for works under my charge in fourth district, Mississippi River, for the period from July 1, 1889, to June 1, 1890.

Very respectfully, your obedient servant,

DAN C. KINGMAN,
Captain of Engineers.

Col. C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

THE CONSTRUCTION OF LEVEES ON THE TENSAS FRONT, FOURTH DISTRICT.

At the date of my last annual report but little work was in progress in levee construction. The Hard Times-Wilson Levee was under contract and was about three-quarters completed. Work upon this levee was carried on by the contractor until the 7th of February, 1890, when the levee was reported finished. It was inspected and received by me February 12, 1890. It was a very large levee, containing 710,163 cubic yards of earth-work, and, including protection-levees and drainage-ditches that were required to be made during its construction, it was necessary to move 798,787 cubic yards of earth. The length of the levee was 53,564 feet, and including protection-levees it was 60,610 feet. It was the largest single levee ever built by the United States on the Mississippi River. The country through which it is constructed was much of it swampy and covered with heavy timber. It was also cut up by lakes and sloughs in such a way that the location was a very difficult one to make. For a portion of its length the levee ran upon a ridge between two lakes, which ridge was so narrow that there was barely room for the levee to rest upon, and in order to secure earth to build it with it was necessary to cut a very long ditch out to the river to partially drain these shallow lakes and uncover the ground upon which the barrow-pits could be placed. At one place the levee had to cross a channel which connected two of these lakes. It was believed that the bottom of this channel would form a very imperfect foundation, and to make the levee secure it was necessary to construct two dams across the channel, at a proper distance apart, in order to form a coffer from which the water could be pumped. After the water was pumped out the logs and fallen trees were removed from this base and two muck ditches were excavated and afterwards filled with good soil. Upon the foundation thus prepared an exceptionally strong levee was erected. It withstood the flood without injury at this place and without serious settlement. It may now be considered safe.

In the latter part of January, 1890, the bank of the river at Point Pleasant, a mile or two above Hard Times-Wilson Levee, began to cave very rapidly and threatened to breach the levee at that point, and so to flank the new levee. To prevent this, it was proposed to construct a new levee at a considerable distance in the rear of the old one. Its construction was commenced by the contractor of the Hard Times-Wilson Levee in February, but owing to the heavy rains and the trouble with seepage water, he made little progress and finally suspended work. Nothing is being done there at present, and the United States inspector has been temporarily withdrawn.

THE PROTECTION OF LEVEES DURING HIGH WATER.

As there was a small sum available for the protection of levees on the Tensas Front during high water, I caused an examination of all the United States levees in my district to be made during the months of November and December, with a view to ascertain where repairs were necessary. A line of levels was run over them all and the result was generally very favorable. But few of the levees were found below grade, and these only for comparatively short distances. The Hard Times Levee where it crosses the bed of Lake St. Joseph was low. Some portions of Evergreen Levee were also low and the same was true of Kempe Levee. Arrangements were accordingly

made to have these levees raised to the proper height. Work at Lake St. Joseph was commenced the latter part of February and completed in March. On Kempe Levee work was commenced in February and it has not yet been entirely completed, owing to the high stage of the river, which rendered it impossible or very expensive to get earth. But the force of labor which had been gathered to repair this levee was used to very good advantage subsequently to protect it from the flood. Nothing has yet been done at Evergreen in the way of permanent repairs. On the 12th of March, 1890, I received telegraphic information that $25,000 had been allotted to me for protection of levees on the Tensas Front. I accordingly sent the steam-boat *General Newton*, with a barge in tow, in charge of Assistant Engineer H. S. Douglas, to the Tensas Front. The barge was loaded with sacks, lumber, tarpaulins, chains, twine, nails, etc., to be used for the protection of levees. At Simmesport I joined the boat myself, and I added there to the cargo a large number of wheelbarrows and shovels, and proceeded to make an inspection of levees on the Tensas Front. My plan was to aid the people in protecting the levees, to make as much use as possible of the local organizations for levee purposes, and to employ local labor to do the necessary work. I endeavored, where the planters were able to do so, to induce them to furnish the necessary labor to protect their own fronts, the United States furnishing material and such tools and engineering assistance as was necessary. Where the work was of considerable magnitude, or where it was inaccessible or a long distance oway from the plantations and places where the laborers lived, I then hired the forces, and if necessary furnished them with tools and subsistence. At this time the river was falling a little, and there appeared to be no immediate danger, but I was satisfied that when the Yazoo wave returned to the river that it would cause a second rise which would probably exceed the first. In the mean time the Morganza Levee, in Pointe Coupée Parish, had been reported in a dangerous condition, and funds for its protection had been provided by the commission. I accordingly telegraphed to New Orleans to have material shipped to Red River Landing, and directed Assistant Engineer W. G. Price to receive it and distribute it where needed, and for this purpose to make use of boats and barges belonging to the Atchafalaya River improvement. Other funds were afterward provided by the Commission to be used for protecting levees, generally in the fourth district, and soon after all the restriction as to the use of money for levee protection was removed.

I returned to New Orleans March 20, and there chartered the steam-boat *Pargoud*, which I loaded with tools, material, etc., and proceeded to Pointe Coupee to assist in maintaining the levees upon this front, which I regarded as the most exposed of them all. I knew that a large amount of water had escaped into the Tensas through the breaks in Arkansas and North Louisiana, and I knew that a portion of this water would return to the Mississippi at the mouth of Red River, and would be superposed upon the Yazoo flood-wave, and I felt sure that it would give a flood of extraordinary height. I met the president of the police jury at Pointe Coupée and went with him to inspect the levees in the parish. I found some work in progress there under his direction. He, as well as the people generally, seemed to be under the impression that the United States had taken charge of all the levees on the river and that they had nothing more to do. This impression gave me no little trouble to remove. People seemed to think that the danger was all over and were unwilling to leave their fields to work on the levees even when paid to do so. This unfortunate apathy caused the loss of much valuable time. When the second rise in the river made itself manifest the people again became alarmed, and after that I had but little trouble in procuring all the labor that was necessary. The people as a rule then worked very hard and were ready and anxious to carry out my instructions. I was rather surprised to find that but little was known among them as to the proper method of protecting levees, and in a number of cases I found them doing work which if not positively injurious did little or no good. The great trouble with the Pointe Coupée system of levees was that they were too low from Smithland to Point Manoir, a distance of about 40 miles. The levees were nearly all low, and there is scarcely a mile in the whole distance upon which it was not necessary to do more or less work.

In order to properly protect the levees on the Mississippi River in the northern part of Pointe Coupee Parish, it was necessary to extend the protection through to the Atchafalaya and down this river on its left bank as far as the levees were good, for breaks in the Atchafalaya system of levees would allow the backwater to come against the Mississippi line, and in this way would cut off the supply of earth for repairing them. The backwater would also weaken them by saturating their bases. I therefore furnished some labor and material for this purpose. The material supplied for use in the Atchafalaya was 12,300 feet of lumber and 7,200 sacks, and labor to the amount of $506.87 was paid for. A great deal of additional labor was furnished by the planters who were interested in holding this line. The work was not successful. Before the flood had reached its extreme height numerous breaks had occurred in the Atchafalaya levees below Simmesport, and the backwater caused no little trouble on the Mississippi line above Morganza. From Barbre's, at the head of the Atchafalaya,

and along Old River to Smithland, a distance of about 9 miles, the levee was generally good. It had been built in part by the United States; some labor, however, was necessary to repair leaks, sloughing places, and to raise it where it was low. Four thousand sacks and about 3,000 feet of lumber were furnished by the United States for this purpose, and $351.69 was paid for labor. The work was directed by Mr. J. Torras for the United States.

From Smithland to Raccourci Landing, a distance of about 13 miles by the levee, the line is a long distance back from the river, as it passes around to the westward of Raccourci, Old River. This levee had been built in part by the United States and the remainder by the local authorities. It had been raised recently by the State and was generally high enough, but it developed a good many bad places during high water, and a good deal of work was done on it by the planters. The United States furnished for the protection of this levee 1,000 sacks and paid $400 for labor. From Raccourci to Morganza, a distance of about 5 miles, the levee was very high and very much exposed, being near the river bank. A great deal of work was necessary upon this portion of the line; most of it had to be raised, and very many leaking and sloughing places developed in the levee, due to the fact that its slopes were too steep for the material of which it was constructed. Work on this portion of the line was under the immediate charge of Mr. Bourgeois. Fourteen thousand nine hundred sacks, 18,520 feet of lumber, and 150 ponnds of nails were furnished by the United States for this work, and $1,601.13 was paid for labor. Tools were also loaned by the United States. The line was successfully held, but it required the utmost efforts of those in charge of it, who worked incessantly day and night during the storm. The Morganza Levee, which was 8,000 feet in length, as before stated, was of good profile, but of insufficient height, and built of sand, which leaked very badly. When the water was near the crown of the levee a walking-stick could be thrust into the bank with very slight pressure and water would come through the hole. One great trouble at this levee was due to the fact that the public road passed behind it, and when the road became muddy people traveled on the top of the levee, and the large number of animals that passed over it injured the rear slope and increased the difficulty of maintaining it. When specially bad leaks appeared earth was dumped into the river upon the slope, until the width of the crown of the levee was sometimes increased as much as 30 feet. This always had the desired effect, but it was very expensive, because the earth had to be brought in wheelbarrows, and the runs were necessarily very long. As the river rose it became necessary to raise the whole 8,000 feet of levee from 1 to 2 feet. Fourteen thousand six hundred sacks, 71,600 feet of lumber, 2,000 yards of cotton bagging were used on this work, and $6,364.15 was paid for labor.

Below Morganza is situated the Grand Levee, a very fine structure, built by the State. It was a little over a mile in length. It was constructed of good material and gave no trouble during the flood, except that it lacked height. It was necessary to raise it about a foot for its entire length. Four thousand three hundred sacks, 12,000 feet of lumber, and 250 pounds of nails were furnished by the United States for this purpose. Four hundred and ten dollars and thirteen cents was paid for labor. In addition to the work done in this portion of the line by the United States a good deal of work was done by a volunteer force that came on the steam-boat *Wheelock*, I understand, from the country about Grosse Tête. No break occurred in this line. From lower end of Grand Levee to the Scott Levee, a distance of about 6 miles, the line was generally low and generally bad. Portions of it had been recently raised by the State, but the new earth was not well sodded, and much of it was washed away by the waves. It was necessary to secure all this by a plank revetment, and to raise the other portions of the levee from 1 to 2 feet. For this purpose the United States furnished 21,300 sacks, 51,025 feet of lumber, 575 pounds of nails, and loaned a large number of tools. The United States also paid for labor to the extent of $1,262.82. A good deal of work along this line was done by the planters, for which, I understand, they were re-imbursed by the parish. The Scott Levee, about 1½ miles in length, was a very fine piece of work, and was built by the United States. It was of good material, but it lacked height to withstand the flood. It was necessary to raise it along its entire length. Near the lower end of it for a distance of 500 or 600 feet it crossed the bed of an old slough. It had given a great deal of trouble while it was being built by settling. and the settling has never entirely ceased. It was particularly low at this point, and a good many leaks developed here. They were all controlled, however, and the levee was saved. Seven hundred and fifty sacks, 11,900 feet of lumber, and 20 pounds of nails were used on this line, and $1,571.77 was paid for labor. Below this levee for about a mile to the St. Francis Church there was a double line of levee, as at Point Manoir. Upon my advice the president of the police jury admitted the water into this basin gradually and in time to save the back levee, although the back levee developed a bad leak, which required a day and night of very hard work to control. From St. Francis Church to Grand Baie levees, a distance of about 8 miles, the levee was generally very low and very bad. With the exception of two large dikes at Waterloo it was a small bank, the natural ground being very high,

and it would not average over 5 or 6 feet in height, It was all too low, and had to be raised throughout its entire length from 1 to 2 feet. For this purpose the United States furnished 34,650 sacks, 37,345 feet of lumber, and 225 pounds of nails. Tools were loaned for this work. The United States paid for labor $2,553 and the parish also contributed a certain amount. This line was breached, as has been stated, in three places, which breaks have since been closed. The Waterloo dikes were nearly 30 feet in height across the upper end of Fausse River. These dikes developed signs of weakness during the flood, becoming very soft and muddy near the base of the land slope, where it was very difficult to strengthen them. The method adopted consisted in building a retaining-wall of sand-bags across the slough inside of the dike and at a proper distance from the toe of the slope, and filling in between this with earth in such a way as to re-enforce the bank by a heavy banquette. The result of the work was successful and the dikes were held.

From the Nina plantation to Point Manoir, a distance of about 2 miles, was situated the Grand Baie Levee. This had all the defects that a levee could have. It was low, it was exposed in places to wave-wash, it was built of poor material, and it had been perforated by crayfish holes, overgrown by bushes, and pierced by the roots of trees that grew on the batture or in its river slope. It gave trouble from the time the water came against it, and a good deal of work had been done upon it by the planters or the parish before the United States took charge of it. It was necessary to raise it, to strengthen it, and to resort to a great many devices to stop leaks. A line of light sheet-piling was tried to cut off crayfish-holes; it succeeded in some cases, but could not be generally used on account of the bushes and trees on the river slope. This line was held, but it required constant watching and labor. The United States furnished 5,000 sacks, 25,554 feet of lumber, and 250 pounds of nails for this work, and paid $1,059.45 for labor.

The Point Manoir Levee has been fully described elsewhere. The work done upon it by the United States consisted in raising it and stopping leaks: 2,000 sacks, 5,700 feet of lumber, 100 pounds of nails were used on this work and $868.65 was paid for labor. This levee was broken and partially destroyed. From Point Manoir to Port Allen, a distance of about 22 miles, the levees were situated in West Baton Rouge Parish. They were generally well cared for, were in good condition, and but little assistance was required from the United States. Six thousand sacks were furnished to the president of the police jury for use at such points on this line as he thought necessary. They were distributed by him, the greater part of them going to Point Manoir. One thousand sacks were put off at Brusley Landing below Baton Rouge and were used at this place. From Baton Rouge to New Orleans the levees were in a much better condition than in Point Coupee. Moreover, there was a line of railroad on each side of the river and these roads had a vital interest in maintaining the line. They furnished a very large amount of material for levee protection to the planters along the line, and I understand that they furnished labor wherever it was necessary to prevent a break or to strengthen the levees. For this reason no work was necessary by the United States here. Four thousand sacks, however, were delivered to the president of the police jury of Iberville Parish at Plaquemine for use in this vicinity. The only breaks which occurred in the levees between Baton Rouge and New Orleans were the Martinez Crevasse, which was since closed, and the Nita Crevasse. Below the city the levees were generally small and they protected, as a rule, only a narrow strip of country. As in the case of the levees above New Orleans, there was a line of railroad on each side of the river which was directly interested in maintaining the line. No assistance was asked from the United States for these levees except where crevasses occurred, and aid was then furnished to close them. The price generally paid for labor was 10 cents an hour, but on Morganza, where a trained force of levee builders was employed, the price was 15 cents an hour.

In addition to the work that was done below the mouth of Red River, about $21,000 was expended for labor for a similar purpose on the Tensas Front, and some $7,000 worth of levee material was used here. For a full description of the kind and quantity of work done, I would refer to the report of Assistant Engineer H. S. Douglas, who was in local charge of this portion of the line.

My experience in protecting levees during this exceptionally high water has led me to think that the levees might be made more secure with but little increase in their total cost. The levees around the head of the bends are very much more exposed to wave action than those along the sides of the straight ridges. The former might well be made exceptionally strong at the expense of the latter. They ought to be given 2 or 3 feet additional height to make them secure against the action of the waves. Where levees are constructed of sand, which should be avoided if possible, a flatter slope than 1 on 3 is necessary to make them safe. Where levees are built on a foundation of doubtful character it ought to be fully explored. A muck-ditch much wider and deeper than the standard one should be adopted and used, and if logs or rack heaps are discovered under the base of the levee they should be removed for at least half the width of the base. Good drainage on the land side of the levee is a

matter of very great importance. No water should be allowed to come against the base of the levee on this side. This point alone often will be sufficient to determine whether a doubtful levee can be held or not. In the sugar parishes, where the line is well drained, the levees, though actually of weaker profile than they are above, were in much better condition this year throughout the period of high water. No trees or brushes should be suffered to grow upon the levees. The best covering they can have is a good sod of Bermuda grass. The use of the levee as a public road is objectionable unless it is given a width of crown of not less than 20 feet, and proper care taken to maintain its height by adding earth from time to time as it is worn away by travel. Ramps should be provided at intervals so that it may not be necessary to ride or drive on the slopes. There is no objection to allowing cattle and sheep to graze on the levees while the water is low, for this improves the sod and keeps down the weeds, but they should all be carefully excluded from the levees from the time the water rises to its base. Cuts in the levees for roadways for flumes, or for pipes are all serious sources of danger, and they should not be permitted under any circumstances. As in the case of all similar works, the levees could be kept in much better condition than they now are by some regular system of annual repairs. To wholly neglect them till the time of high water comes, causes necessary work to be done in the most expensive and least durable manner.

CREVASSES.

The following is a condensed account of the crevasses that occurred in the Mississippi River below Vicksburg during the flood of 1890. The crevasses are described in the order in which they are situated on the river from Vicksburg down, and not according to the dates upon which they happened.

The Lake Concordia Break.—This crevasse is in Lake Concordia at its western extremity. It occurred on the 22d of April at about 10 o'clock a. m. It was at a point where the levee was about 6 feet high, and at this time the water was about 1 foot below the crown. The levee had shown no special signs of weakness, but it was of insufficient profile, and was subjected to a head of water greater than it was designed to resist. It is said that a stream of water burst through the embankment about half way up the slope, then the crown of the levee fell in, and in a short time the break was 50 feet wide. On the morning of the 23d it was 200 feet wide "with a very swift current washing through it and tearing its channel all to pieces." On the 10th of May it was 837 feet wide, with a mean depth of 13.35 feet, an average velocity of 4.21, and a discharge of 47,042 cubic feet per second. An effort was made to secure the ends of the levee by driving piles. It succeeded at one end of the crevasse and failed on the other.

Arnauldia.—This break is about 1 mile below the town of Vidalia. It occurred on April 23. It was due to wave wash, and it is thought that it might have been prevented if there had been a force to look after it, but the people were alarmed by the Concordia Crevasse, and were all engaged in saving their property, and no labor was to be had. The break on May 11 was 455 feet wide, 2.42 feet deep, and was discharging 1,871 cubic feet a second.

Henderson-Ashley.—The crevasse, like the others described, is in a levee on the right bank of the river, and is situated about 12 miles below Natchez. It was caused by the water running over the top of the levee. Like the preceding one it might have been prevented if there could have been a sufficient force to guard it. It occurred on April 23. It enlarged very rapidly to a width of 400 feet. On May 3 it was 700 feet wide and on May 12 it was measured with the following results: Width, 873 feet; mean depth, 7.77 feet; velocity, 5; discharge, 33,916 cubic feet a second.

These were all the crevasses that took place in my district, above the mouth of Red River. For a more detailed account of them, as well as for a description of the mode of measuring them, I would refer to the report of Assistant Engineer H. S. Douglas upon this subject, which is transmitted herewith.

CREVASSES BELOW THE MOUTH OF RED RIVER.

Raccourci Break.—This crevasse is situated in the line of levee that crosses Brunette Point, extending from Raccourci Landing to the bend of Old River. The break was on the plantation of Mr. Horace LeDoux. The levee was an old one, having been built in 1866, and was of a very weak profile. The levee was a leaky one, and had given trouble in former high waters. The crevasse occurred at 9 p. m., April 23. It is said that without previous warning a stream of water as large as a flour barrel burst from the ground at the toe of the land slope of the levee, and in a few minutes later the crown fell in, and the crevasse enlarged very rapidly. Three days later the break was 342 feet wide, 6 feet deep, and discharging 13,500 feet per second. On May 22 it was again measured, with the following results: Width, 380 feet; depth, 3.30

feet; mean velocity, 4.32; discharge, 5,417 cubic feet a second. There had been a fall at this point of 4.4 feet from the highest water. This office having furnished the necessary material, the work of closing this crevasse was begun by the planters May 23. The crevasse was completely closed May 28.

The following is a statement of labor and material used for this purpose:

Sacks, 10,000 delivered	$516.25
Lumber, 24,000 feet delivered	388.00
Nails, 4 kegs at $3.50	14.00
Labor, 309 days, at $1	309.00
Total	1,219.25

There was a small amount of material left over, but that has not yet been returned. The total length of the structure built to close the break was 450 feet. The greatest depth of water through which it was carried was 4½ feet and the average depth in front after the break was closed was 3½ feet. The work of course could not have been done for anything like the above sum if it had been undertaken when the flood was at its height. The crevasse was closed according to a plan prepared by me, and which will be hereafter described.

Upper Morganza.—This levee at the point where the break occurred is situated at a distance of at least a quarter of a mile back from the river bank and is concealed from view from the river by a heavy growth of cottonwoods. The levee was of good material and well sodded, but it lacked height and it had been raised with sacks and earth on an average 1.1 feet, though at some places the raising amounted to a great deal more than this. The break took place during the night of April 21, near midnight. The storm at this time was very severe and the waves were driven by the southeasterly gale against the levee with great violence. The water was almost on a level with the top of the sacks, and every wave broke over them. As the storm increased the waves began to move the sacks themselves. For a time the guards were able to replace and secure them, but finally a breach was made nearly 50 feet wide through the line of sacks; the water poured over the levee, which was about 14 feet high; the men were driven from their work, and in a short time the levee was cut through and the crevasse was formed. When I visited the break at 8 o'clock the next morning it was about 400 feet wide and appeared to be discharging about 50,000 cubic feet a second. It was a very angry looking break. The swamp had not yet filled with water and there was a fall of several feet right in the throat of the crevasse. The water dashed in among the trees, which were trembling and falling, and the noise of the rushing water could be heard for more than a mile. Four days later, when the swamp had been filled by this and other crevasses and the river had been lowered at this point some 3 or 4 feet, the break was 650 feet wide and the discharge reduced to 40,320 feet per second. On the 22d of May, the crevasse was 790 feet wide, 8 feet deep, with a mean velocity of 5 feet and a discharge of 31,600 cubic feet per second. The level of the water at the crevasse was not less than 7 feet below what it was when the levee broke. The levee was not the one which was constructed by the Mississippi River Commission.

The Morganza.—This levee was built by the Mississippi River Commission and the State of Louisiana jointly during the winter of 1886–'87. It was about 8,000 feet in length, and was constructed with the utmost care, and was a very good structure of its kind. The only faults with it were these, that it was built of river sand, which washes very easily when the sod is once broken, and which does not make a perfectly tight bank, and also that it was not of the proper height. It was given a net height of a foot and a half above the high water of 1882. But this flood wave must have been locally depressed here because the crevasse was then open, besides the levee had settled somewhat and in many places was below net grade. In building the levee great care was taken to secure a perfect bond between the bank and the natural surface of the ground. In places where stumps and buried drift-logs were found the muck-ditch was made as much as 14 feet wide, and all foreign material was removed. The levee was very finely sodded, and its slopes were as smooth and true as those of a fortification. The levee had been raised during the high water from 1 to 2 feet along its entire length, and this work was the best of its kind that was done anywhere in my district. The new earth was protected by boards nailed to pickets driven in the crown of the levee near its exterior crest, and inside of the board a breadth of cotton bagging was placed to keep the earth from washing under or through the revetment. On all exposed portions of the levee the new earth was 6 feet thick and was retained on the land side by boards secured as in front.

The break occurred on the night of April 22. The cause of it can never be absolutely determined. The storm on this night was fearful, and the waves in the river running very high. There was nobody on the levee at the time that it broke. The guards, who were all people living in the vicinity, had become demoralized by the

breaks that had occurred the night before, and had all left the work to try to save their stock and other property from the overflow. I had examined the levee on the 22d and found that the effect of the upper break, which was only about 300 feet from Morganza, had been to lower the water to about the level of the crown, and it seemed to me that the levee was safe unless the upper break should extend downward far enough to involve it.

During the night of the 22d the storm came from the east, and had a clear sweep right up the river from Bayou Sara to Morganza, a distance of about 12 miles. The effect of this must have been to back the water up in the head of the bend, and its surface must have been elevated by this cause several inches at least. At Bayou Sara I know, for I was there that night, the water was 4½ inches higher for a short time during the night than it was in the evening or the morning when the gauge was read. I believe that during the storm the water rose again above the top of the main levee, and that the force of the waves was sufficient to wash out the sand from behind the revetment, and thus permitted a flow over the top of the levee which melted away as soon as the sod was broken. In fact, a place has been found on what remains of the levee where this very thing had taken place, and the water had actually begun to cut a channel in the crown, but had been stopped by the fall in the river, due to the other crevasse. The people living in the vicinity believe that the levee was cut, but I think that the explanation that I have given is the true one. I visited the crevasse on the 23d at 4 p. m. At this time the opening was about 600 feet wide, and I estimated the discharge at 90,000 cubic feet a second. On the 25th at 10 a. m. I visited the crevasse and found it 1,227 feet wide, with a discharge of about 117,800 cubic feet. The swamp behind the levee was filling up and the current was greatly reduced, and it looked more like a river than a crevasse. The levee was washing away on the south end at the rate of about 300 feet in twenty-four hours. As it had cost at the rate of about $10 to the running foot the loss was very serious. As I expected this would be so, I made preparations to protect the end by a willow mattress as soon as the break occurred. I telegraphed for a barge-load of rock from New Orleans on the afternoon of the 23d, and on the afternoon of the 25th it arrived at the levee. In the mean time I had a force engaged in cutting willows, and on the 1st of May the mattress was completed and sunk on the river slope of the levee about 60 feet from the break. The mattress was built of fascines each 50 feet long and 1 foot in diameter; they were lashed together side by side with heavy rope so as to form a mat that was 50 by 125 feet. Thus built it was very stiff crosswise and very flexible lengthwise, so that when in place it could wrap around the levee but could not slip down off the slope or double up if not well supported. To sink it rock was placed in double sacks and tied to the rope lashing in such a way that it could not slide off when the mat assumed an inclined position on the slope of the levee. The levee soon caved up to the mat after it was placed and, as was expected, the mat wrapped around the end and protected it perfectly. As the construction of the mat was novel I send herewith a drawing from which it can readily be understood. When the mat was placed on May 1 the break was 2,180 feet wide. It was measured on May 22 and it was 2,543 feet wide, showing that there had been a loss of bank of 360 feet between these dates. Part of this took place where the mat was, in order to permit it to adjust itself around the end of the levee. The loss here was perhaps 120 feet, as the mat was placed 60 feet from the break, and the rest, about 240 feet, must have been lost from the north end. This was not a very serious matter, however, being only about 10 or 12 feet a day. It would have been impossible to place a mat there under any circumstances, because this part of the levee being between two crevasses was an island, and barges of rock and willows could not have been taken to it owing to the strong currents. The mean depth of this crevasse on May 22 was 13.117 feet, its mean velocity 4.373 feet per second, and its discharge 146,034 cubic feet. The water-surface at this date was about 6.6 feet below high water.

The Snead Crevasse.—This break is in a small levee of weak profile. It is about 3 miles below Morganza on the same side of the river. It occurred on the night of April 21 at 9 p. m., and was due to the force of the waves and possibly to drift-logs driven against the levee. Four days after the break it was 90 feet wide and discharging about 2,000 cubic feet per second. The break ceased to enlarge ten days after it happened. Its width May 22 was 147 feet; mean depth, 3.56 feet; velocity, 6 feet; discharge, 3,139 cubic feet. This crevasse could easily be closed, but no one seems anxious to undertake it.

The Lanaux Crevasse.—This break is about 500 feet below the one just described. It happened about the same time, and was due to the same cause. Four days after the break it was 110 feet wide and was discharging about 2,640 cubic feet. It ceased to widen in about ten days. On May 22 its width was 151 feet; mean depth, 3.36; mean velocity 6 feet, and discharge 3,044 cubic feet. The water-surface at both of these breaks was at this time about 5 feet below flood height. Like the former this break could readily be closed.

The Fanny Riche Crevasse.—This crevasse occurred in an old levee about 2¼ miles be-

low the one just described. The levee was situated very near the river bank, and it was expected that it would cave into the river in a few years, and for this reason it had not been raised at the time that the other levees in the vicinity were being repaired. It was, therefore, very low and of very weak profile. It had a width of only about 18 inches on the crown, and during the flood it had been necessary to raise it as much as 20 inches. This work was done by means of a plank revetment and the backing of earth in sacks. At the time that the break occurred the water was almost as high as the top of the new work. At about 9.30 a. m., April 21, a large steam-boat passed up the river, and it is said that the swells from this boat loosened and washed away some of the planks from the revetment; this allowed the waves to attack the new earth, and before a sufficient force of laborers could be collected to repair the damage the levee was breached and a crevasse was formed. When I saw the break at 12.30 p. m. it was about 240 feet wide and it was discharging about 20,000 cubic feet of water per second. It enlarged rapidly for the first ten days, after which there was very little change in its condition. On the 22d day of May it was measured with the following results: Width, 845 feet; mean depth, 7.37 feet; average velocity of discharge, 4.35 feet per second, and the discharge at this time was 27,118 cubic feet per second. It has been proposed to close this crevasse and some of the planters living in this vicinity applied to me for aid. But inasmuch as the batture was only about 35 feet wide, and as the depth of the crevasse at the north end for a distance of 225 feet averaged about 11½ feet and the velocity in this section was nearly 6 feet, I felt that it would be a very difficult and expensive operation to close the break at the present stage of the river, and I did not feel authorized to furnish any assistance.

The Preston Crevasse.—This break is situated in the levee nearly opposite Bayou Sara, and like the one just described the levee was an old one and was too low. It had been raised during the flood by a double tier of sacks, and at the time the break occurred the water was running over the sacks in places. The break occurred about midnight of April 21; it was doubtless due to some of the sacks being washed off the levee by the force of the waves. The break widened rapidly and soon attained a width of 200 feet with a discharge of about 10,000 cubic feet per second. As the river fell it became evident that the crevasse could be closed, and accordingly work was commenced on the 12th of May under the direction of Mr. Bennett Barrow, and was completed May 17, at which time the flow of water was completely stopped. The material used for the closure of this break was furnished by the United States, and the labor, I understand, was paid for with money furnished by the Louisiana Lottery Company. The method of closing was the same as that used at the Raccoureci break, and which will be hereafter fully described. The material furnished by the United States consisted of 40,000 feet of lumber, 20,000 sacks, and 4 kegs of spikes, the whole valued at $2,400, and I was informed that the labor account amounted to a little over $1,500, making the total cost of closing the crevasse a little less than $4,000. The total length of the structure, built to close the crevasse, was 660 feet; the greatest depth of water along the line upon which the break was closed was about 8 feet and the average depth about 4 feet. In the throat of the crevasse, after the break was closed, there was found a depth of water as great as 45 feet and the average depth was considerably over 30 feet. The width at the time of closing from end to end of the levee was 213 feet. About 3,000 feet below this break are two other small breaks which are known as the Taylor crevasses. The lower one of these occurred first. The condition of the levee was the same as the one already described, if anything it was a little lower and the raised work of course was higher. The first break occurred on the morning of the 21st of April. At the time that I saw it, about 10 a. m., it was about 50 feet in width and was discharging about 3,000 cubic feet of water per second. The other break, which was about 600 feet north of No. 1, was about 40 feet in width and occurred later in the day. Both these crevasses were closed by Mr. Barrow at the same time that he closed the Preston break. The first one was closed by a line of inch boards used as a sheet-piling and re-enforced with sacks filled with earth. There had been no wash below the base of the levee, and this line was driven right at the foot of the river slope. The width of the break at the time of closure was 203 feet. No. 2 was closed at the same time as No. 1 and in a similar manner. Its width was then 51 feet. As there was very little water flowing through these breaks at the time they were closed, no special account was kept of the cost of closing them; it amounted to but little and is included in the cost of closing the Preston break. This completes the list of crevasses which occurred in Pointe Coupée Parish; the next two are in West Baton Rouge on the right bank of the Mississippi River.

The first of these is the *Point Manoir Crevasse.* The conditions here were very peculiar, and it certainly seems that this break was a preventable one. At this point there was a double line of levee; the front levee was a very old one, of strong profile and well constructed, although it lacked height; but it was situated along the caving portions of the river, and it was thought that it would ultimately be destroyed by the caving of the bank. For this reason the State, during the winter of 1886–'87, built what

is known as the New Point Manoir Levee, extending down the river a distance of about a mile, where it is connected with the old levee. The old and new levees thus inclose a rectangular space about 850 feet wide by 5,000 feet long. For some reason or other the front levee had never been cut so as to permit the water to come against the new levee. At the time I saw it, about March 20, the water was standing about a foot below the crown of the old levee. The current of the river was setting in very strongly in the bend, and it seemed to me that there was great danger that the front levee would cave into the river. If it did this, I felt quite sure that the rush of water against the new levee would break it and in this way a crevasse would be formed at a place which ought to be doubly safe. These works were not United States levees, and as the ground between the two lines was occupied and under cultivation, I did not feel authorized in overflowing it without the consent of the owners. They declined to consent, and accordingly I visited the president of the police jury of West Baton Rouge and urged him to fill the space between the two levees by means of a siphon or a box-flume, which could be controlled. I advised him to fill the space at the rate of 6 or 8 inches a day, so as to give the new levee time to consolidate, and to be prepared, in case the new levee showed signs of weakness, to shut off the supply of water and hold the front levee until the new line could be repaired and strengthened. He promised to do this, but the work was done so slowly and so frequently delayed from causes which it is not necessary to mention here that at the end of April the basin was only partially filled. At about midnight on the 30th of April the front levee caved into the river near the upper end. The rush of water caused the opening to enlarge until it had attained a width of 600 feet. This large flow of water so suddenly precipitated upon the back levee caused it to give way, and a breach was formed in it within a few hours after the first levee broke. The width of the break in the new levee became finally equal to 571 feet. In six days, however, after the break occurred its width was only about 300 feet, its mean depth about 4 feet, and its discharge 12,000 cubic feet per second. This break was closed by the parish authorities on the 17th of May. Work was commenced on the 9th. The method used consisted in driving the line of sheet-piling from opposite sides of the break along a curved line on the inside of the levee. As the lines of sheet-piling approached each other the force of the current became so great that they were obliged to use a crib structure similar to that used at the Preston and Raccourci breaks. The entire crevasse could have been closed by this latter method in much less time and at a much less expense. The length of the structure used to close it was 980 feet, the average depth of water along the line on May 23 was 2.82 feet; the water in the river at this time was 4.82 feet below high water.

The next break was the *Lobdell Crevasse.* This occurred in a levee on the west bank of the Mississippi, opposite the western extremity of Profit Island. It occurred at about 4.30 p. m., April 22. The levee was a large and high one, standing about 1.7 feet above the highest water of this year. It had a wide crown and good, full slopes, and the entire levee is well sodded with Bermuda grass. It is said that the water burst out of the ground immediately at the foot of the land slope in a large stream, as big as a flour barrel, and in a few seconds the top of the levee collapsed and the crevasse was formed. The break enlarged rapidly, the caving being mainly at the north end. On the 26th of April it was 956 feet wide, 6 feet deep, with a discharge of 57,300 cubic feet per second. The water from this break overflowed a very fine and highly cultivated tract of country, and the people were very anxious to attempt to close the break. They desired to close it by means of a patent sheet-piling, a method in which I had no confidence. I, however, furnished them about 15,000 sacks to use in closing the break. They continued to work upon it for about a week, but the rapid current scoured out the piles and the work was finally abandoned. On the 23d of May the crevasse was measured, with the following results: Width, 1,981 feet; mean depth, 7.22 feet; average velocity, 4.12 feet; discharge, 58,892 cubic feet per second. The river at this time was 5.8 feet below the flood height. On the 23d of May a second attempt was made at the north end of the break to close a deep channel by the sheet-piling process, in a hope that a part of the discharge through the crevasse could thus be shut off and the injury that it was causing proportionately reduced. No report of this work has yet been received, but it is understood that it was not successful or that it did not accomplish the purpose.

The next break was the *Martinez Crevasse.* This was situated on the left bank of the river, about 8 miles below Baton Rouge. It occurred on the night of April 22, during the storm; it is said to have been due to the existence of a rice flume. The water was very near the top of the levee at the time the break took place. Twenty-four hours after the break occurred it attained its maximum width, which was 124 feet. I estimated the discharge through it at 4,800 cubic feet per second. This break threatened to inflict very great damage on a large portion of country which hitherto had been safe. It was feared that the water from it would join with the water from the Nita Crevasse and thus overflow the entire valley on the left bank of the river from Baton Rouge to New Orleans. Immediate effort was made to

close the crevasse. The Mississippi Valley Railroad and the planters living in the vicinity contributed labor and material. The work was done under the immediate direction of Mr. James D. Houston, a planter living in the vicinity. The work was fairly started April 24 and was completed April 28. The length of line upon which the closure was made was about 500 feet; the style of work was similar to that of the Preston break, but the structure was not very skillfully designed, and the material was not all used to the best advantage. There was an excessive strength in some portions of it and in others it was hardly strong enough. The distance between the levees and the river bank was not very great, and as a result the crevasse channel extended nearly to the bank before the break was closed. The depth in the throat of the crevasse was about 42 feet. On the inside of the line of cribbing it varied from 6 feet to 20 feet. The cost of closing this break was very great. The railroad company contributed about $13,000 in labor and material, the Mississippi River Commission about $5,800 in material and service of steam-boat, and the planters contributed a very large quantity of labor, more than was necessary, in fact, of which no account was kept. The closure of the break, however, was worth all that it cost.

For a more detailed account of the breaks from Red River down I would refer to the report of Assistant Engineer W. J. Hardee, which is transmitted herewith.

The next break was the *Nita Crevasse*. This is situated on the left bank of the Mississippi River, about 5 miles above College Point. The break occurred on the night of March 14. It is said to have been due to the existence of a rice flume in the levee. It enlarged very rapidly in spite of every effort to control it, and on the 24th of March it had attained a width of 642 feet, an average depth of 14 feet, a mean velocity of nearly 10 feet, and a discharge of about 90,000 cubic feet per second. It was believed at this time by the managers of the Mississippi Valley Railroad that the break could be closed. The injury that it inflicted upon them was very great, for the line of their railroad was only a few thousand feet from the levee, and the track was completely cut in two by the crevasse, and their business with the city of New Orleans was completely interrupted. They proposed to cross the break on the line of the levee by a strong timber trestle-work, and to make use of this structure as a bridge from which to close the break. If such a structure could have been put across the crevasse it is probable that the break could have been closed, but great difficulty was experienced in handling the long piles which it was necessary to use when the trestle got out into the swift current. About 75 feet of trestle-work was carried out from the north end, but in the mean time it was found impossible to secure the south end, and the trestle-work was abandoned. The crevasse continued to enlarge in spite of the efforts to control it. In the latter part of April an attempt was made to place a mattress on the end of the levee similar to the one used on the Morganza break, but at this time the river had fallen somewhat in the vicinity and the base of the levee was nearly out of the water, and the crevasse seemed rather to be in the bank itself than in the levee. The mattress constructed was a very fine one of its kind. It was 42 feet wide and 112 feet long. It was built under the direction of Foreman Venus, an employé of the Mississippi River Commission. The plant belonging to New Orleans Harbor was used for this purpose. The mat was dropped at the south end of the break, but it was not large enough to afford the necessary protection, and it was undermined and finally disappeared, and the crevasse continued to enlarge. A very large amount of money was expended by the Mississippi Valley Railroad Company in attempting to close or to control this crevasse. The Mississippi River Commission contributed about $5,400 in labor, material, and service of boats for this same purpose. On the 9th of May the crevasse was measured, and it then had a width of 2,892 feet, a mean velocity of 9.28 feet, a mean depth of 15 feet, and a discharge of 402,556 cubic feet per second. This discharge seemed so great that by direction of the Commission I caused it to again be measured on the 21st of May. This time a current meter was used and a line was taken at a considerable distance inside the break. The section was carefully sounded. The discharge thus determined was 356,985 cubic feet a second. The gauge at College Point had in the mean time fallen about eight-tenths of a foot. This would reduce the discharge through the 2,892-foot opening not less than 25,000 cubic feet per second. This quantity added to the measured discharge gives 381,985 cubic feet, which checks pretty well for work of this kind.

These are all the crevasses which occurred above the city of New Orleans. Below the city there were a great many small breaks, most of which, however, have been closed. The Myrtle Grove, however, is still open. It is situated in the right bank of the Mississippi River, 35 miles below New Orleans. There are really two breaks at this point. They occurred during the morning of April 21, and were about 300 feet apart. All enlargement ceased four days after the breaks happened. The original levee was 5½ feet high. At the time the breaks occurred the water was very nearly at the top of the levee. The crevasses were due to sloughing. On the 9th of May the crevasses were measured with the following result: No. 1, width, 295 feet; velocity, about 5 feet; mean depth, 3½ feet; discharge, 5,150 cubic feet per second. No. 2, width, 540 feet; velocity, 2.18 feet per second; mean depth, 5⅓ feet; discharge, 6,474

cubic feet per second. No effort has yet been made to close these breaks, but I have retained some material that was left over from closing other breaks in this vicinity, to be used at Myrtle Grove in case it is desired.

Besides those breaks already described there are a large number of others below the city, a description of which has been furnished by Mr. H. S. Bell, secretary of the New Orleans and Gulf Railroad Company, as follows:

"No. 1. February 13, crevasse occurred at St. Sophie, about 35 miles below New Orleans. Break about 75 feet wide, and closed on February 15.

"The levee was about 5 feet high on side next the public road, and 3 feet high on batture side. This levee was a very old one, and a new levee had been built on the batture between the old levee and the river. The new levee was built entirely of sand, and when the high water came against it it melted away, and left the protection of the plantation entirely to the old levee, which was in a very bad condition and full of cray-fish holes, and requiring constant attention and patching up. Immediate cause of this break was supposed to have been cray-fish holes. The break was closed by crib-work in the shape of a horseshoe, on the river side of the levee. The cribs were driven down in a double row of boxes about 4 feet square, and filled in with sacks of earth as fast as the cribs were down. The crib-work was braced from the outside, and afterward sacks and loose earth were filled in on the river side, making a comparatively dry levee.

"No. 2. February 13, a crevasse occurred as Corinne, about 8 miles below New Orleans. This break was closed on February 15. The levee at Corinne was about 5 feet high. Cause of crevasse, cray-fish holes. Break was closed by crib-work, built straight across, joining the two ends of the levee, and filled in with straw and sacks of earth well braced on the outside. The crevasse was 25 feet wide.

"No. 3. February 23, at Bertrandville, three breaks occurred; one on Brulard's place, and two at Pierre Bertrand's place. These breaks were from 10 to 15 feet wide.

"The levee in this neighborhood is about 4 feet high. One of the breaks was caused by an old rice flume being forced out, and the other two breaks by drift logs driven by the wind against the levee. Work was commenced on these breaks immediately, and they were closed the same day by crib-work, filled in with sacks of earth, in the direct line of the levee.

"No. 4. February 24, crevasse occurred at New Texas Landing, about 55 miles below New Orleans. This break was reported to be about 30 feet wide, and was closed on February 28. Do not know the height of this levee, the cause of the crevasse, nor how it was closed.

"No. 5. March 4, a crevasse occurred at St. Sophie, about 35 miles below New Orleans. Crevasse was 30 feet wide, and closed on March 10. Immediate cause of this crevasse was cray-fish holes near an old rice flume, which was washed out in a very short time, and the increased depth of water through the rice flume caused a great deal of trouble in stopping this crevasse. Closed the crevasse by a lengthy V-shaped crib-work on the river side of the levee. The levee in this neighborhood was about 5 feet high.

"March 7, a small break, about 15 feet wide, occurred in the levee at St. Sophie, about 300 yards from the crevasse of the 4th instant. This break was closed on the 9th instant by a straight crib-work in a direct line of the levee. Caused by cray-fish holes.

"No. 6. March 14, a small break occurred at Empire Mills, 47 miles below New Orleans. The crevasse was about 15 feet wide, and closed on same day. Levees in this neighborhood from 4 to 5 feet high.

"No. 7. March 19, three breaks occurred in the Bohemia Levee, just below the terminus of the New Orleans and Gulf Railroad. Break from 30 to 50 feet wide. There is an immense batture in front of the old levee at Bohemia, and a new levee had been constructed between the old levee and river about 100 yards distant from the old levee. The new levee had not been fascined, and being built on the batture, from river sand, was soon washed away by the force of the high water; and the old levee was completely honey-combed by cray-fish and fiddlers. These crevasses were closed on March 30. The levee at Bohemia is from 4 to 5 feet high on the road side and 3 to 4 feet on the river side.

"No. 8. Mach 21, a crevasse occurred at Harlem, about 38 miles below New Orleans. The levee at this point is 8 feet high on the road side and 5 feet high on the river side. Break was caused by an old rice flume giving way. It was closed on March 25 by a double row of cribbing, horseshoe-shaped, on the river side. Outside, below the cribbing, was filled with sacks of earth, and inside or river row of cribbing was filled with loose earth.

"No. 9. March 26, a small break about 10 feet wide occurred at Harlem. Work was commenced on it immediately, and it was closed on the 27th by a straight row of cribbing in the direct line of the old levee. The cause of this was a cray-fish hole, which had been previously boxed up.

"No. 10. March 26, a small break, about 15 feet wide, occurred at Martin's, near

Empire Mills, about 47 miles below New Orleans. A cray-fish hole was the cause of this crevasse. The levee was 5 feet high, and the break was closed on the same day by straight crib-work, joining the two ends of the levee.

"No. 11. March 26, two breaks at Corinne; one 30 and one 25 feet wide; closed the same day. Here the levee is about 5 feet high on the road side and 3 to 4 feet high on the batture side. The break was closed by a V-shaped crib-work, filled with sacks and loose earth. The cause of this crevasse, cray-fish holes.

"No. 12. March 22, a small break at Woodland, about 10 feet wide, and closed the same day by straight crib-work, joining the two ends of the levee. Here the levees are about 4 feet high. Cause of break unknown.

"No. 13. March 28, two small breaks occurred in the New Orleans and Gulf Railroad Levee, at Bohemia, about 50 miles below New Orleans. One of the breaks was about 10 feet wide, and the other 6 feet; both were closed on the same day as made. One of these breaks was caused by an alligator hole, and the other by a cray-fish hole. The levees are about 5 feet high.

"No. 14. April 2, one of the crevasses at Bohemia, just below the terminus of the New Orleans and Gulf Railroad, which had been closed on March 30, broke out again, and is still open.

"No. 15. April 21, seven breaks occurred at St. Sophie and immediate vicinity. Cause was the violent storm on that date. The levee at St. Sophie is about 5 feet high, and all of the breaks were successfully closed on April 30. The United States Government furnished 60,000 feet of lumber, 20,000 sacks, and 12 kegs of spikes for closing these crevasses; of this lumber, 5,000 feet was delivered to Haspel & Davis for closing another crevasse, and about 3,000 feet to T. S. Wilkinson for Myrtle Grove, and there is still remaining at St. Sophie about 15,000 feet of this lumber unused. These breaks were closed by crib-work on the river side, either horse shoe-shaped, or V-shaped, as usually found most expedient.

"No. 16. April 21, two small breaks occurred at Thibauts, 43 miles below New Orleans. Breaks 10 to 12 feet wide, and closed on April 26. These breaks are caused by the severe storm of the 21st. The levee in this neighborhood is about 5 feet high, and the break was closed by a straight crib-work, in the direct line of the levee.

"No. 17. May 10, a small crevasse occurred at Harlem, about 15 feet wide, and closed on May 10. It was caused by a cray-fish hole. Here the levee is about 7 feet high. The break was closed by straight crib-work.

"There was very little work in the way of raising levees in the immediate vicinity of the breaks just enumerated. Several places levees on the lower coast, between New Orleans and Bohemia, were raised, by piling up sacks filled with earth, and in some cases the water raised to fully 1 foot above the crest of the old levee; but this was not the case at any of the levees at which breaks occurred. There was not an instance of the crevasses being caused by the river washing over the levee and cutting it away."

These were all upon the left bank of the river, and it will be seen that they were all small and very quickly closed. On the right bank there was a break at Riceland, 51½ miles below the city of New Orleans. It was a small, low levee, and was attributed to the effect of waves. It occurred on the 19th of April, and attained within six days a width of about 100 feet and a discharge of about 4,800 cubic feet per second. An attempt was made to close it about the 25th of April, and the work was finished a few days later. Labor was furnished by people living in the vicinity, and the United States furnished material as follows: 46,790 feet of lumber, 3,000 sacks, 5 kegs of nails, and 25 pounds of twine of a total value of $547.43. No account has been furnished of the amount of labor that was necessary to close the break. There was also a break at Live Oak plantation, about 30 miles below New Orleans. This break occurred about midnight of March 19. Its width was 116.7 feet, its mean depth 6½ feet, its average velocity 7¾ feet per second, and its discharge 5,881 cubic feet per second. There was a heavy growth of willow on the batture in front of the break which tended to diminish the velocity of the discharge. The plantation behind this levee was unoccupied, and the levee was not very closely watched. It is thought that the break was due to injuries caused by the cray-fish or some other burrowing animals. The work of closing the crevasse was commenced soon after it occurred, and it was finally closed on April 10, but even at this time there were some leakages through the work. The United States Government furnished 93,000 feet of lumber, 20,000 sacks, and about 40 kegs of nails for this work. The New Orleans, Fort Jackson, and Grand Isle Railroad expended about $7,000 towards closing the break, and the Citizens' Bank of New Orleans, which owned land behind the levee, contributed about $4,000 more, making the total cost of closing the break between $13,000 and $14,000. In addition to these breaks on the Mississippi River there were a large number of others on Bayou Des Glaise. There were also two breaks in Old River, one at Barbre's Landing, and the other about half-way from this point to the Mississippi River. A list of these breaks, with the time that they occurred and their size,

with the amount of water escaping through them at the time they were measured, is given as follows:

Crevasses in Old River and Bayou des Glaise.

Name.	Date of break.	Cause of break.	Width of crevasse.	Depth in crevasse.	Velocity per second	Discharge.	Height of levee.	Amount raised.	High-water mark below top.	Present surface below top.	Material used in raising.
IN OLD RIVER.			*Feet.*	*Feet.*	*Feet.*	*Cu. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
Ferguson	Apr. 22	Cray-fish.	153	6	0.5	459.0	4.5	.....	1.0	4.0	
Barbre	Apr. 21	....do	212	3.5	4.0	7,208.0	4.5	1.25	.....	3.7	
BAYOU DES GLAISE.											
No. 1	.....	Slough	598	4.6	4.8	13,203.8	6.8	.....	1.5	4.0	
No. 2	Apr. 21	Ran over	180	1.0	3.3	594.0	3.7	.....	*2.0	0.5	
No. 3	Apr. 21	....do	54	2.5	6.4	864,0	4.5	.....	*1.6	1.2	
No. 4	Apr. 12	....do	40	1.4	4.3	240.8	4.5	.....	*1.8	1.2	
No. 5	Apr. 10	....do	1,600	0.3	0.5	240.0	3.0	.....	*1.8	0.8	
No. 6	Apr. 21	....do	1,500	†1.7	.....	.....	.....	.....	.....	.....	
No. 7	Apr. 22	Cray-fish	175	5.0	1.8	1,415.0	3.0	1.0	.....	2.3	
No. 8	May 1	....do	70	2.0	2.2	308.0	3.0	1.2	0.1	2.4	
No. 9	Apr, 22	....do	102	1.0	1.5	153.0	4.5	2.3	0.2	2.6	Earth and sacks.
No. 10	Apr. 22	Ran over	435	†1.0	.....	.....	.....	.....	.....	.....	
No. 11	Apr. 22	....do	180	†1.8	.....	.....	.....	.....	.....	.....	
No. 12	Apr. 21	....do	60	1.1	1.3	85.8	3.0	1.5	0.2	2.6	Earth and boards.
No. 13	Apr. 21	....do	50	3.0	1.9	285.0	3.0	1.5	0.2	2.6	Do.
No. 14	Apr. 21	....do	195	2.3	1.5	672.7	4.3	2.0	.....	2.4	Do.
No. 15	Apr. 24	Slough	75	2.3	1.0	172.5	4.5	2.3	0.1	2.6	Do.
No. 16	Apr. 24	Ran over	60	2.0	0.9	108.0	4.0	0.5	.....	2.5	Do.
No. 17	Apr. 24	Slough	123	6.2	1.2	915.1	4.5	1.5	0.2	3.0	Earth.
No. 18	Apr. 24	Ran over	150	†2.0	.....	.....	.....	.....	.....	.....	
No. 19	Apr. 24	....do	418	†1.0	.....	.....	.....	.....	.....	.....	
Red Fish post-office.											
No. 20	Apr. 28	Slough	90	4.0	0.8	288.0	3.5	1.5	0.5	2.5	Sacks.
No. 21	Apr. 21	Ran over	760	0	0	.....	2.0	2.0	.....	2.0	New levee.
No. 22	Apr. 28	....do	850	0	0	.....	1,5	1.5	.....	1.2	Do.
Hamburgh.											
No. 23	Apr. 23	....do	(‡)	0.2	1.5	1,980.0	1.5	1.5	.....	1.2	Do.
No. 24	Apr. 28	....do	(§)	.....	.....	.....	.....	.....	.....	.....	
No. 25	Apr. 24	....do	2,100	0	0	.....	3.0	1.0	.....	2.8	Do.
No. 26	Apr. 22	Slough	50	5.5	0	.....	2.7	.....	0.2	3.0	Closed inside.
No. 27	Apr. 27	Ran over	60	0	0	.....	3.0	0.5	.....	3.0	Earth.
No. 28	Apr. 28	Slough	408	4.0	2.0	3,264.0	5.0	.....	0.5	3.5	
Old Church.											
No. 29	Apr. 22	Ran over	600	0	0	.....	3.5	0.5	.....	3.0	Earth and planks.
No. 30	Apr. 22	....do	200	5.5	1.3	1,908.0	4.0	2.9	0.5	3.5	Do.
No. 31	Apr. 22	Reported cut cray-fish.	564	4.0	2.0	4,512.0	6.5	.....	2.0	5.0	
No. 32	Apr. 22	Cray-fish	700	4.0	2.7	7,560.0	4.5	0.5	0.5	2.5	Earth.
Big Bend											

* Above.
† When water was highest.
‡ 1¼ miles.
§ Ten miles; no levee; bank 1.2 feet above present level of water; ran over 1.3 feet deep at highest water; this and No. 23 and 25 ran back into bayou from crevasses above in Big Bend.

From No. 21, 2 miles below Hamburgh, on Bayou des Glaise, to No. 26, below Old Church, a distance of about 20 miles, there are practically no levees on the bayou. At Hamburgh a 2-foot levee was thrown up and held, keeping out the water; below a small ridge had been thrown up, but was washed away. In places above Ham-

burgh old levees exist, but for 10 miles out of 18 miles the banks are high and there are no levees. This entire unprotected front was overflowed from the rear. The breaks at Nos. 30, 31, and 32, at the lower end of Big Bend, filled the swamps and the surplus then returned to the bayou over this unprotected front. No. 31 was reported as having been cut, but there was no proof.

Location and measurements of crevasses in the fourth district, Mississippi River, 1890.

Name.	Date of—		Width.	Depth.	Mean velocity per second.	Discharge per second.	Bank.	Location (below Cairo.)	Remarks.
	Break.	Measurement.							
			Feet.	*Feet.*	*Feet.*	*Cu feet.*		*Miles.*	
Lake Concordia	Apr. 22	May 10	837	13.35	4.21	47,042	R.	(*)	
Arnauldia	Apr. 23	May 11	455	2.42	1.70	1,871	R.	701¼	
Henderson-Ashley	Apr. 23	May 12	873	7.77	5.00	33,916	R.	711¾	
Raccourci	Apr. 23	May 22	380	3.30	4.32	5,417	R.	(†)	Closed May 28.
Upper Morganza	Apr. 21	May 22	790	8.00	5.00	31,600	R.	788¾	
New Morganza	Apr. 22	May 22	2,543	13.117	4.378	146,034	R.	789¼	
Sneed	Apr. 21	May 22	147	3.56	6.00	3,139	R.	792¼	
Lanaux	Apr. 21	May 22	845	7.37	4.35	27,118	R.	792¾	
Preston	Apr. 21	May 23	213	4.60	.....	.....	R.	794¼	
Taylor No. 1	Apr. 20	May 23	203	3.40	.....	.....	R.	801⅝	Closed May 17.
Taylor No. 2	Apr. 20	May 23	51	3.70	.....	.....	R.	802¼	Closed May 11.
Point Manoir	Apr. 30	May 23	571	2.82	.....	.....	R.	802¼	Do.
Lobdell	Apr. 22	May 23	1,081	7.22	4.12	58,892	R.	809	Closed May 17.
Martinez	Apr. 22	May 23	124	19.70	.....	.....	R.	816½	
Nita	Mar. 14	May 23	2,892	15.00	9.28	402,556	L.	842½	Closed Apr. 28.
Corinne	Feb. 13	.....	25	.....	.....	.....	L.	899	
Do	Mar. 26	.....	30	.....	.....	.....	L.	.....	Closed Feb. 15.
Do	Mar. 26	.....	25	.....	.....	.....	L.	973½	Closed Mar. 26.
Bertrandville	Feb. 23	.....	10–15	.....	.....	.....	L.	.....	Do.
Live Oak	Mar. 20	Mar. 26	116	6.50	7.75	5,881	L.	990½	Closed Feb. 23.
Woodland	Mar. 22	.....	10	.....	.....	.....	R.	991½	Closed Apr. 10.
Myrtle Grove	Mar. 21	May 6	540	5.50	2.18	6,474	L.	992½	Closed Mar. 22.
Do	Mar. 21	May 6	295	3.50	5.04	5,153	R.	.....	
St. Sophie	Feb. 13	.....	75	.....	.....	.....	R.	999½	
Do	Mar. 4	.....	70	.....	.....	.....	L.	.....	Closed Feb. 15.
Do	Mar. 7	.....	15	.....	.....	.....	L.	.....	Closed Mar. 10.
Do	Apr. 21	Apr. 23	54	12.00	10.00	6,480	L.	.....	Closed Mar. 9.
Do	Apr. 21	Apr. 23	22	9.00	10.00	1,980	L.	.....	Closed Apr. 30.
Do	Apr. 21	Apr. 23	71	9.00	10.00	6,390	L.	.....	Do.
Do	Apr. 21	Apr. 23	50	6.00	10.00	3,000	L.	1,000½	Do.
Do	Apr. 21	Apr. 23	21	5.00	10.00	1,050	L.	.....	Do.
Do	Apr. 21	Apr. 23	40	5.50	10.00	2,200	L.	.....	Do.
Do	Apr. 21	Apr. 23	38	4.75	10.00	1,705	L.	.....	Do.
Harlem	Mar. 21	Mar. 23	50	8.00	11.00	4,312	L.	.....	Do.
Do	Mar. 26	.....	10	.....	.....	.....	L.	.....	Closed Mar. 25.
Do	May 10	.....	15	.....	.....	.....	L.	1,003½	Closed Mar. 27.
Thibauts	Apr. 21	.....	10	.....	.....	.....	L.	.....	Closed May 11.
Do	Apr. 21	.....	12	.....	.....	.....	L.	1,008½	Closed Apr. 22.
Empire Mills	Mar. 14	.....	15	.....	.....	.....	L.	1,008½	Do.
Do	Mar. 26	.....	15	.....	.....	.....	L.	.....	Closed Mar. 14.
Bohemia	Mar. 19	.....	30–50	.....	.....	.....	L.	1,012½	Closed Mar. 26.
Do	Mar. 28	.....	6	.....	.....	.....	L.	.....	Closed Mar. 30.
Do	Mar. 28	.....	10	.....	.....	.....	L.	1,015½	Closed Mar. 28.
Riceland	Apr. 19	.....	60	6.00	8.00	4,800	R.	1,017	Closed Apr. 25.
New Texas Landing	Feb. 24	.....	30	.....	.....	.....	L.	1,020½	Closed Feb. 28.

* In line of levee around Lake Concordia 3½ miles south of a point 692 miles below Cairo.
† In a line of levee on Raccourci River 6¼ miles south of a point 770 miles below Cairo.

CLOSURE OF CREVASSES.

As soon as a crevasse occurs and its destructive effects become felt there is always a great demand that it should be closed. It is generally impossible to close them for a day or two after they break, if the levee is of any considerable height. But when the country back of the levee becomes partially filled with water, so that the velocity in the crevasse is somewhat reduced, they can, if the conditions are favorable, be closed with material, which can always be easily obtained, and at a cost which would seem to be justifiable. The circumstances would be considered favorable where the levee is situated at a considerable distance from the river, so as to leave a batture of a hundred feet or more in width, and also where the water on the bottom is not more than 8 feet in depth. While it is not impossible to close a crevasse in a greater depth of water, the risk and the expense become very much greater after the depth passes the limit which I have given. A great many crevasses were closed in my district during

the present high water, and while the methods were somewhat varied, the following design, which is illustrated in the plan, section, and elevation transmitted herewith, contains all of the best features of the various methods which were used, and is essentially the same as that employed at Raccourci and Preston. The materials used are 2 by 4 inch scantling, inch boards 12 inches wide, and sacks. The method consists in constructing a trestle bridge with light bents, placed about 2 feet apart, starting from each end of the levee on the river side and far enough from the crevasse opening so that there is no danger of the structures being turned during the process of closure. This bridge is carried outward from the batture until it gets far enough away from the levee to pass beyond the deep hole which is almost always excavated in the throat of the crevasses; the two ends of the bridge then turn towards each other, and are built in this direction till they meet. For a depth of water of 6 feet six piles should be used in each bent; they are capped with boards, as shown in the section, which serve at the same time to brace them. The bents are fastened together longitudinally by four lines of boards on edge, and the bridge is floored as indicated upon plan so as to leave an opening about 3 feet wide in the center. All parts of the structure should be firmly nailed together so as to secure the greatest amount of stiffness. Outside of the inner row of piles a strip of 2 by 4 scantling is firmly nailed to the caps to hold the heads of the small piles which are afterwards put in to form the grating. While the bridge is being constructed a force is employed filling sacks with earth. The sacks must be all filled full and well and tightly sewed. As they are filled they are carried upon the bridge and piled up until a sufficient number of them have been placed to form a levee which will completely close the crevasse. After this is done a sufficient number of pickets made of 2 by 4 scantling are prepared and quickly driven, as indicated upon plan, so as to form the grating on the land side of the bridge close enough to keep the sacks from washing through. When this is ready a large force of men should be assembled upon the bridge, and at a given signal they throw the sacks through the opening. The work must be carried on as rapidly as possible, and must not cease until the pile of sacks rises above the surface of the water. Any leakage which then develops can be stopped by dumping earth from the bridge upon the river side of the levee. All the piles for the trestles as well as for the grating are driven with hand mauls, and no heavy pieces of timber or expensive appliances are required for the work. Where the water is not more than 3 or 4 feet deep the structure can be simplified by omitting the two piles on the river side of each bent. The sacks, however, ought to be thrown into the water through the opening as indicated on the large trestle, in order to give a safe width of base to the levee to enable it to make a good joint with the surface of the ground. This kind of work has been successfully used for a short distance where the water was as much as 14 or 15 feet deep.

THE FLOOD OF 1890.

The high water of 1890 will long be remembered in the Mississippi Valley as the highest and the largest flood that has ever occurred of which we have any authentic record. There are, to be sure, a few points on the river where the conditions have been modified by cut-offs where the present flood has been surpassed by some preceding ones, but these cases are exceptional and are easily accounted for, and do not affect the great portion of the river. The flood was doubtless due to the exceptionally heavy rainfall in the Ohio Valley, and also in the valleys of the subordinate tributaries of the river, for the great tributary, the Missouri and the Mississippi itself, were neither of them at a very high stage at any time during the flood. The flood heights at the various stations of observation, the form of the flood wave and the various phenomena connected with it can best be studied by a graphical representation, and I have therefore prepared a drawing which shows the plan of the river with the points at which gauges are established marked upon it. It also shows the location of the levees, the railways, the bluffs, and other topographical features. An examination of this map will show that the gauges are well placed to give a good idea of the flood along the whole river, and that they are near enough together to disclose all of the abnormal features of the wave.

The drawing also shows, by the heavy lines, the gauge heights at the various stations where observations were taken during the entire dangerous period of the flood; that is to say, from the 1st of March until about the 5th of May. I have also put upon this drawing, for the purpose of comparison, the corresponding hydrographs of the flood of 1882. At Red River Landing I have also given the gauge curve for Barbre's Landing plotted to the same absolute zero. This gauge, it will be noted, is at the head of the Atchafalaya River, and a study of it serves to show the influence that the Atchafalaya flood exerted upon that in the Mississippi; I have also marked the location of the different crevasses that occurred in my district, and I have indicated the dates at which they occurred, the dates at which their discharges were measured, and also the volume of discharge of each. I have also given the discharge curves for the Red River Landing section, and for the Carrollton section, and have

noted the discharges at Warrenton, Natchez, and Baton Rouge at the dates at which they were taken.

A study of this sheet shows that there were two flood waves, the first of which culminated between the 15th and 20th of March, and the second between the 20th and the 25th of April. The first wave was a normal one for all points above Donaldsonville; that is to say, the flood water was entirely confined within the banks by the levees. The second one was an abnormal one, and was influenced and modified by the crevasse water which had escaped through the crevasses above Vicksburg, and which returned to the river at the mouth of the Yazoo and at the mouth of Red River.

The hydrographs of Vicksburg, St. Joseph, and Natchez are similar throughout; they form a group which differs from those below them, and they show very plainly, when compared with the curves for Red River Landing and Bayou Sara, the influence of the Atchafalaya as an outlet.

At the beginning of March, as shown by the curves, the Atchafalaya was lower than the Mississippi, and it was acting therefore as an outlet, and its effect is evident from the fact that the Red River Landing gauge was relatively much lower than those above.

The first crevasse in Tensas Basin, above my district, occurred in the early part of March, the Sappington was on the 8th of March, and this was followed by the Raleigh on the 15th and the Luna on the 18th. As the crevasse water reached the head of the Atchafalaya, this gauge began to rise and soon came to the level of the Mississippi at Red River, and the two curves are coincident. After the 15th Barbre's gauge rises above that at Red River Landing and the Atchafalaya becomes a tributary instead of an outlet. The influence of this tributary is very peculiar and very marked in this case. By examining the discharge curves before alluded to, we find a maximum discharge at Red River Landing occurring about the 17th and 18th of March. It is to be regretted that there were not a greater number of discharge observations taken at Red River Landing between the 5th and 18th of March, because the curve is not very fully delineated. It is quite apparent, by comparing it with the curve at Carrollton, that the discharge of March 18 could not have been the maximum discharge. However, we see that the discharge fell off very rapidly after the 18th of March, and that it did not again attain as great a volume until about the 15th of April, nevertheless, the Red River Landing gauge maintains the same height from the 15th up to the end of March, which would seem to indicate that the return water had been heaped up upon the surface of the Mississippi River at this point, and had increased its height without increasing its discharge. The fact that it did this is proved, first, by the study of the gauges above Red River Landing we see that the Vicksburg, the St. Joseph, and the Natchez gauges all fell about 1.5 feet from the 15th to the 31st of March. This is exactly what should have taken place, due to the diminished discharge, and that from the 1st of April to the 15th of April these gauges gradually rose again and attained, on the 15th of April, a height about equal to what they had on the 15th of March, at the time of the March flood. But at Red River Landing there was no fall after the 15th of March, but from the 1st of April to the 15th of April the gauge height increased 2.4 feet, and this same fact is observed to a lesser extent at Bayou Sara, 35 miles below Red River Landing; here there was a slight fall of about .3 foot up to the end of March, and from the end of March to the 15th of April there was a rise of about 2.2 feet, or a gain of 1.9 feet from the crest of the March flood. At Baton Rouge the fall to the end of March was greater than at Bayou Sara, and subsequent rise was less. At Plaquemine, still lower down the river, the fall in March was still greater than at any of the points above to Red River Landing and the subsequent rise was also less, showing that this heaping up of the water at Red River Landing due to the return crevasse water, made itself felt down as far as Baton Rouge, a distance of 70 miles, and that it did not make itself felt at Plaquemines, a distance of 90 miles.

The first crevasse to occur in my district was the Nita Crevasse, a break which took place in the levee on the left bank of the river about 5 miles above College Point. The break, in spite of all efforts to control it, increased rapidly, and on the 22d of March it had a discharge of about 90,000 cubic feet a second. Its influence is very plain upon the College Point gauge, 5 miles below. Its effect was sufficient to prevent the College Point gauge from ever again attaining a height as great as that which it had in March. We observe on this hydrograph a gradual fall from the time that this crevasse occurred until the end of the flood. The discharge of the Nita Crevasse increased very rapidly; from 90,000 cubic feet a second on the 22d of March, it increased to 400,000 cubic feet a second on the 7th of May. At that time it became equal to one-third of the entire discharge of the river. Notwithstanding this enormous escape, however, through this outlet, the actual fall directly traceable to this crevasse, or the gauge at College Point from its highest point, was only about 1.9 feet, and since this highest point was nearly 24 feet, if the fall had corresponded to the loss of discharge it ought to have amounted to as much as 8 feet. At Carrollton the influence of this crevasse as an outlet can be traced to be sure, but its influence was very

much less than at College Point, and the fall due to it may be stated to be about 1 foot. This, even, at a time when this escape must have been at least one-fourth of the entire discharge of the river.

As the second flood wave approached its culmination, the river below the mouth of Red River Landing attained a height greater than any of which we have any authentic record, and the levees were taxed to a point beyond which they were ever expected to resist. On the 21st of March a very severe storm set in; very heavy rainfall, accompanied by a gale from the east and southeast; the levees, saturated as they were by long exposure to a height of water which reached almost to their crowns, were unable to withstand the force of the storm and yielded at a great many places. Above the mouth of Red River there was a crevasse at Lake Concordia, another at Arnauldia, another in the Henderson-Ashley Levee.

Below the mouth of Red River crevasses occurred during the period of the storm at Raccourci, Upper Morganza, New Morganza, Smead, Lanaux, Fannie Kiche, Preston Taylor, Lobdell, and Martinez, some nine or ten crevasses in a distance of about 60 miles. These crevasses discharged in the aggregate, within two to three days of the time when they occurred, a volume of nearly 300,000 cubic feet a second. The effect of this enormous loss of water from the river was to cause a rapid lowering of the surface upon that portion of it directly influenced by the crevasses, and we note at Bayou Sara, Baton Rouge, and Red River a loss of height of 1 foot or more in a period of two or three days. The greatest fall is at Baton Rouge, as it is below all the important breaks; the least fall is at Red River Landing, because it is above most of the breaks and because this loss of water was largely compensated by the increased amount of water which it drew from the Atchafalaya as soon as the Mississippi began to fall.

Above the mouth of Red River, at Natchez, the abrupt fall is very slight, amounting only to 3 or 4 inches. At St. Joseph and Vicksburg, the fall was normal and was simply due to the fall in the river above. It therefore may be seen that the influence of these enormous outlets thus suddenly let loose at the flood height was something, to be sure, but it was very insignificant in comparison with the amount of water drawn from the river. It is further to be noted that its effect is almost entirely felt below the points at which the crevasses occurred, and that at a comparatively few miles above the crevasses the effect ceases and amounts to nothing. There could not be a more forcible object lesson than this upon the worthlessness of outlets as a means of controlling floods.

We find, in addition to the crevasses which I have mentioned, others occurring at Live Oak, Harlem, Riceland, St. Sophie, and Myrtle Grove. All of these breaks occurred below the City of New Orleans; most of them were closed, to be sure, within a week or two after they happened, but Myrtle Grove has not yet been closed, but in examining the Carrollton gauge-curve we can not trace any effect due to any of these breaks below the city. A comparison of the discharge curves at Red River Landing and Carrollton would seem to indicate that there was a less loss of water through these crevasses that I have described as occurring between those two points than results from adding together the discharges that I have given. For example, about the end of April, when all the crevasses were open, there is a difference in the discharge between these two points, as shown by the curves, of less than 500,000 cubic feet a second, yet the escape through all the crevasses at this time must have been at least 700,000 cubic feet a second; but this difference is accounted for by the fact that the river was falling and the water passing the Carrollton section was necessarily greater per second than that passing Red River Landing section, due to the reservoir capacity of the main trunk of the river itself between these two points, for the river between these two points was lowered some 2 or 3 feet in a period of a few days, and its enormous volume of water would furnish a very considerable discharge in itself; in addition, the rainfall, which was very heavy below Red River, would be sufficient to add materially to the discharge.

IMPROVING MISSISSIPPI RIVER (NO LIMIT).

Money statement.

(*a*) Levees on Tensas Front:

July 1, 1889, amount available		$87,190.84
March 19, 1890, amount transferred to protection of levees	$10,000.00	
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	48,073.42	
July 1, 1890, amount covered by uncompleted contracts made during the fiscal year ending June 30, 1890	21,419.63	
		79,493.05
July 1, 1890, balance available		7,697.79

(*b*) Protection of levees, fourth district:		
Amount allotted from act of August 11, 1888		$114,000.00
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$95,839.87	
July 1, 1890, outstanding liabilities	147.49	
		$95,987.36
July 1, 1890, balance available		18,012.64
(*c*) Protection of levees on Tensas Front, fourth district:		
July 1, 1889, amount available		19,371.77
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889		19,371.77

IMPROVEMENT OF THE HARBOR OF NEW ORLEANS, LOUISIANA.

The tendency of the Mississippi River at New Orleans, as elsewhere, is to attack, undermine, wash away, and destroy its concave banks, whereby the crossings are rendered more abrupt, and the bars at the points or convex banks extended. This action is exceedingly injurious at places like New Orleans, where the city occupies both banks of the river, for in the bends, levees, streets, and warehouses are gradually undermined and destroyed, while the growth of bars elsewhere prevents access to wharves and docks. To resist and overcome this tendency to change, and to hold the river permanently in its present lines, is the sole object sought to be attained in the improvement of New Orleans Harbor.

The works employed to accomplish this end now consist of submerged spur-dikes with sloping crests, placed in the bends at proper intervals, the object being to prevent erosion by checking the velocity of the current along the shore, to force the line of deepest water farther from the shore, and, if possible, to induce deposit between the spurs, thus reducing and equalizing the slope of the bank. The top of these spurs is generally placed at about the low-water line, and the crest slopes downwards at an angle of about 1 on 3, so as to place the toe at the deepest portion of the river. The axis of the spur is placed perpendicular to the direction of the current or else is inclined slightly up-stream. The spurs, which rest on a wide mattress, are built of timber, willow-brush, and stone.

The portions of the river where this kind of work was considered necessary were as follows:

	Feet.
The Carrollton Bend, length	10,000
The Greenville Bend, length	33,000
The Gouldsboro Bend, length	6,500
The third district, length	2,500
Total	52,000

In pursuance of this general project the following work had been done prior to July 1, 1889: A continuous mattress about 400 feet in length had been placed at the head of the Carrollton Bend. This kind of work has since been abandoned. Six spur-dikes had been constructed in the Gouldsboro Bend, which completed the work proposed at that point. One very large spur had been partly built in the Greenville Bend near the company's canal. A survey of the harbor had been made, and plans and estimates prepared for the continuation of the work. The plant had been put in good order, and a large quantity of lumber, brush, and rock had been procured and was conveniently stored for spur-dike construction.

During the past year the dike in the Greenville Bend was completed, and a second spur about 1,000 feet below it built. This was all the work that the approved project called for in that locality for the present. In addition to this four spur-dikes were built in the third district of the city of New Orleans, completing the improvement at that point.

Spur No. 1, in the Greenville Bend, is worthy of special mention as being the largest structure of its kind ever placed in the Mississippi River or elsewhere, so far as I know. It contained in round numbers 3,400 cords of willow brush, 80,000 feet of lumber, 2,000 tons of rock, 5,500 pounds of wire, 60 kegs of nails and spikes, and 8,000 pounds of iron rods and chains. Its length was 430 feet; its maximum height 60 feet, and the depth of the water at its outer end was 152 feet at low water.

Dike No. 2 was a little longer than the one just described, but it was only about 48 feet high and contained very much less material. These two spurs have been exposed to the recent high water. What their condition now is can not be determined till the river reaches a stage low enough to permit soundings to be taken over them. The bank has not caved at any point within the area which they are designed to pro-

tect. The velocity of the current next the bank has evidently been reduced, and the line of greatest velocity has been pushed out from the bank. I think that they are accomplishing all that is required of them, and that there is every reason to anticipate that the spurs will be found in good condition, and that the mean slope of the bank in the area influenced by them will be somewhat reduced.

The spurs in the third district differed from those heretofore constructed in the harbors, in this, that they were carried above the low-water line. The river at this point had encroached so far upon the city that it had been necessary to move the levee back until it occupied one-half of a street running parallel to the river, and practically destroyed the street. It was therefore important to stop absolutely the recession of the bank line, and if possible to reclaim a little land from the river. The spurs were therefore carried up over the batture and connected with the levee, and at the point of junction they were given the same height as the levee itself. The subaqueous portion of the spurs was constructed in the same manner as those heretofore described, and the spur was prolonged from the low-water line to the main levee by a bank of earth of the proper dimensions, which was protected from wave-wash and scour due to overfill by a layer of gravel or broken stone 9 inches thick, upon which a rough stone pavement of like thickness was laid. This covering extended out upon the batture for a distance of 20 feet from the toe of the up-stream slope and 50 feet from that of the down-stream one. It was also carried out to connect with the foundation mattress. The work was done last autumn under favorable circumstances, with a low river, good weather, and a well-trained force of workmen under the immediate direction of a zealous and competent engineer, who thoroughly understood what he had to do. The work was therefore very good of its kind, and its cost fell considerably below the estimates. As in the case of the Greenville spurs, the exact condition of the work can not yet be fully determined. This much is evident, however. The paved spurs have resisted the action of the waves and current perfectly. There has been no loss of bank, and there has been a heavy deposit of silt of from 1 to 3 feet in thickness upon so much of the batture as has thus far been uncovered by the falling river. I feel confident that this work will be a complete success, and I believe that this type may be advantageously adopted for the protection of the caving banks at many points higher up the river. One great advantage that it offers is its cheapness, and another is that the loss of one or more spurs does not necessarily involve the loss of the whole system, even if it takes place at a time when no funds are available for repairs.

The actual cost of the field-work in the third district, which is the only proper standard of comparison, was $33,574.48, and it protects about 3,000 feet of caving bank, where the average depth of water is 90 or 100 feet. If this protection proves entirely satisfactory, as I believe it will, it then presents a method of bank protection costing only about $11 a running foot, a cost which is certainly very moderate.

I send herewith a drawing showing the location of the spurs in the third district, also showing a section of each spur and the details of construction of the bank protection.

There yet remains under the present project six spurs to be built in the Carrollton Bend. The following material is now on hand for this work:

4,840 tons rock, at $2	$9,688.00
30,000 feet lumber, at $10.90	327.00
28 kegs nails, at $3	84.00
1,420 pounds galvanized wire, at 4 cents	56.80
115 cords brush, at $1.68	193.20
30,000 pounds iron rods, etc., at 3½ cents	1,050.00
Total value	11,399.00

The work will be begun as soon as the river reaches a stage low enough to render it possible. The proposed location and mode of construction of the spurs is shown upon the accompanying drawing.

As this project was based upon a survey that was made a year and a half ago, and as the destructive forces of the river have not been idle during this period, it will doubtless be necessary to make some changes in the dimensions if not in the location of these spurs.

The only very valuable property which is immediately endangered by the caving of the bank in this locality is the large and fine wharf, warehouse, and elevator belonging to the Louisville, New Orleans and Texas Railroad. I regard this property as in a very critical condition, and I am by no means sure that work done this season will be in time to save it. I am informed that there has been a great deal of scour in front of the wharf during the present high water, and that a great many piles have washed loose, and that it has been necessary to replace them with 90-foot sticks. This would seem to indicate that the bank is assuming a dangerously steep slope, and an extensive caving of the bank may be looked for at any time as the river falls. It will be

remembered that I recommended that this work should be done last year, in preference to that in the third district.

The plant and material belonging to the work in New Orleans Harbor is all in good order and ready for use, excepting the tug, which on the night of May 8 took fire and burned to the deck. The boat had a few hours before returned from the Nita Crevasse, whither it had been sent to be used in measuring the discharge. The cause of the fire is unknown, but after a careful investigation I am satisfied that it was unavoidable and that no one was to blame. The loss will amount to about $2,000. The boat is now being repaired and will be ready for use by the time it is needed.

The commercial statistics of the port of New Orleans are now being compiled. They can not be completed, however, before the close of the fiscal year. The same remarks will apply to my financial statement.

IMPROVING MISSISSIPPI RIVER (NO LIMIT).

Money statement.

New Orleans Harbor:		
July 1, 1889, amount available		*$126,734.65
Amount disallowed by Chief of Engineers (over-payment)		.04
		126,734.69
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$78,215.07	
July 1, 1890, outstanding liabilities	4.26	
		78,219.33
July 1, 1890, balance available		48,515.36
Amount (estimated) required for completion of existing project		500,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		200,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

THE RECTIFICATION OF THE RED AND ATCHAFALAYA RIVERS.

The objects to be attained by the rectification of the Red and Atchafalaya rivers are threefold, namely:

First. To prevent the further deterioration of the channel of the Mississippi River at and near Red River Landing, due to the action of the Atchafalaya as an outlet.

Second. To afford at all stages of the two rivers a safe and easy entrance from the Mississippi to the Red River and its tributaries for all classes of vessels and tows that navigate them.

Third. To secure like advantages for the Atchafalaya and its connecting waters. And it is also required as a condition that these results should be attained without disturbing the high-water regimen of the rivers and streams involved, whereby property would become subject to overflow which is now safe.

The approved project requires the construction of the following works: A series of low dams, not exceeding six in number, is to be built across the Atchafalaya River below the mouth of Bayou des Glaizes to prevent the further enlargement of the Atchafalaya and to limit its outlet capacity. These dams have a maximum depth over their crests of 7 feet at extreme low water, and at high water permit a discharge over them equal to the entire flow of Red River, say 200,000 cubic feet per second. In addition to this, a low dam is to be built across Old River from the west shore of Turnbull's Island to the mainland, and between the old mouth of Red River and the head of the Atchafalaya. The crest of this dam is to have a suitable elevation above the obstructions in the Upper Old River, its object being to force the Red River when below a certain stage to flow through Upper Old River, which, before the present conditions induced by the enlargement of the Atchafalaya, was its natural and better channel. To still further control the flow of Red River at low and intermediate stages, it is proposed to build a jetty from the lower end of Turnbull's Island along the middle of Old River and extending outward into the Mississippi. This jetty is to have a height in due relation to that of the Red River Dam, and a form in plan such as to deliver the Red River water to the Mississippi with the minimum amount of shock. Its effect will be to force the current, during the falling and low stages of the rivers,

* This is the correct amount available July 1, 1889, not $126,634.65, as printed in Appendix V V, page 2721, of the Annual Report of the Chief of Engineers for 1889.

to flow from the Red to the Mississippi River, and the current of the latter river sweeping past the end of the jetty will prevent the formation of the bar that is usually found at the mouth of a tributary. These works will also secure an easy entrance to the Atchafalaya; for this river, being deprived of all water from the Red River (when the level of the dam is reached), will become a proper outlet of the Mississippi, and will be permitted to take an amount of water (to be regulated by the contraction works in the Atchafalaya) sufficient to maintain a channel through Lower Old River large enough and deep enough for all purposes of navigation. The Atchafalaya, though by these means reduced to an outlet of the Mississippi for a few months during the low-water season, will at other times carry the flood discharge of Red River, which will be ample to maintain its channel; and there is no reason to fear that it will deteriorate, as do the ordinary outlets of the Mississippi River. The same forces that are now acting to enlarge it will still act, under proper direction and control, to maintain its channel.

These works, being all of low relief, and situated in wide and deep portions of the rivers, will not interfere with their high-water regimen, and no place in the valley which is now safe will be rendered liable to overflow.

In addition to this, the annual projects for many years have contained provisions for maintaining navigation through Old River during the low-water season by various temporary devices, such as dredging, washing with the wheels of steam-boats and tugs, dragging along the bottom scrapers attached to steam-boats, contracting the channel by temporary wing-dams, blowing up the mud lumps with dynamite, etc. These expedients have succeeded when the conditions were favorable, and have generally failed wholly or in part when they were not. But they always afforded some relief, and while they certainly cost a great deal of money in the aggregate, the work was doubtless worth what it cost. The worst that can be said of work of this character is that it is of no value after the season in which it is done. It is therefore greatly to be desired that the appropriations for this work should be large enough to permit the permanent works soon to be finished, in order that this annual drain may cease.

It may perhaps be well to state here that it has often been asserted that, but for the work done from year to year by the United States for the purpose of maintaining a navigable channel through Old River during the low-water season, this channel would have become so filled up as to be practically closed, and the Red and Atchafalaya rivers thus divorced from the Mississippi; a condition which is regarded by certain persons not interested in the navigation of the river as very desirable. But this is not the case. Nothing of the kind would have taken place. It may be definitely stated that the influence upon the permanent condition of Old River produced by any work that has been done there in the last ten years is infinitesimal, if it is not absolutely zero. A greater change is wrought upon the bottom of Old River in three or four days by a sudden flood in Red River when the Mississippi is low than could be produced by washing and dredging all summer, and such floods occur almost every year.

In pursuance of the general plan thus briefly sketched out the following permanent work had been accomplished up to the 1st of July, 1889:

As stated in my annual report for the year ending July 1, 1888, a survey of the reach of the Atchafalaya below Bayou des Glaizes had been made to determine the proper location for the dams, a plant for the work had been procured, necessary temporary buildings had been erected on the bank, a deep well had been driven to secure a supply of potable water, and the sill for Dam No. 1 had been constructed. During the succeeding year a dredge, four dump-scows, and two large and well-equipped quarter-boats were added to the plant, the dam on Sill No. 1 was built, and the sill for Dam No. 3 was nearly completed, and some 26,000 tons of rock were quarried out and distributed for use at the different works in my district. Lumber and other material had also been procured and was on hand for the work. The balance available for the continuation of this work on July 1, 1889, was $88,560.23. Of this sum it was proposed to set aside $20,000 for the maintenance of a navigable channel through Lower Old River during the low-water season 1888 and 1890 by dredging or other temporary devices; also to set aside $5,000 for the protection of existing works till September 1, 1890, and also a sum sufficient to care for the plant and material when not in use until September 1, 1890. With what then remained it was proposed to complete Sill and Dam No. 3, in the Atchafalaya River, and to proceed with the construction of the dam near the head of Turnbull's Island as far as the funds then available would allow.

In accordance with this plan Sill and Dam No. 3 were completed August 27. The mode of construction was the same as in Dam No. 1. That is to say, the sill was first placed across the river between the low-water lines. It was formed of a single layer of mattresses. These mats were each 75 feet wide, 304 feet long, and 3 feet thick. They were built of willow brush and poles in layers at right angles, and were held together by timber clamps. These mats were sunk in succession, side by side across the river, thus forming a sill 304 feet wide. That portion of the sill between the

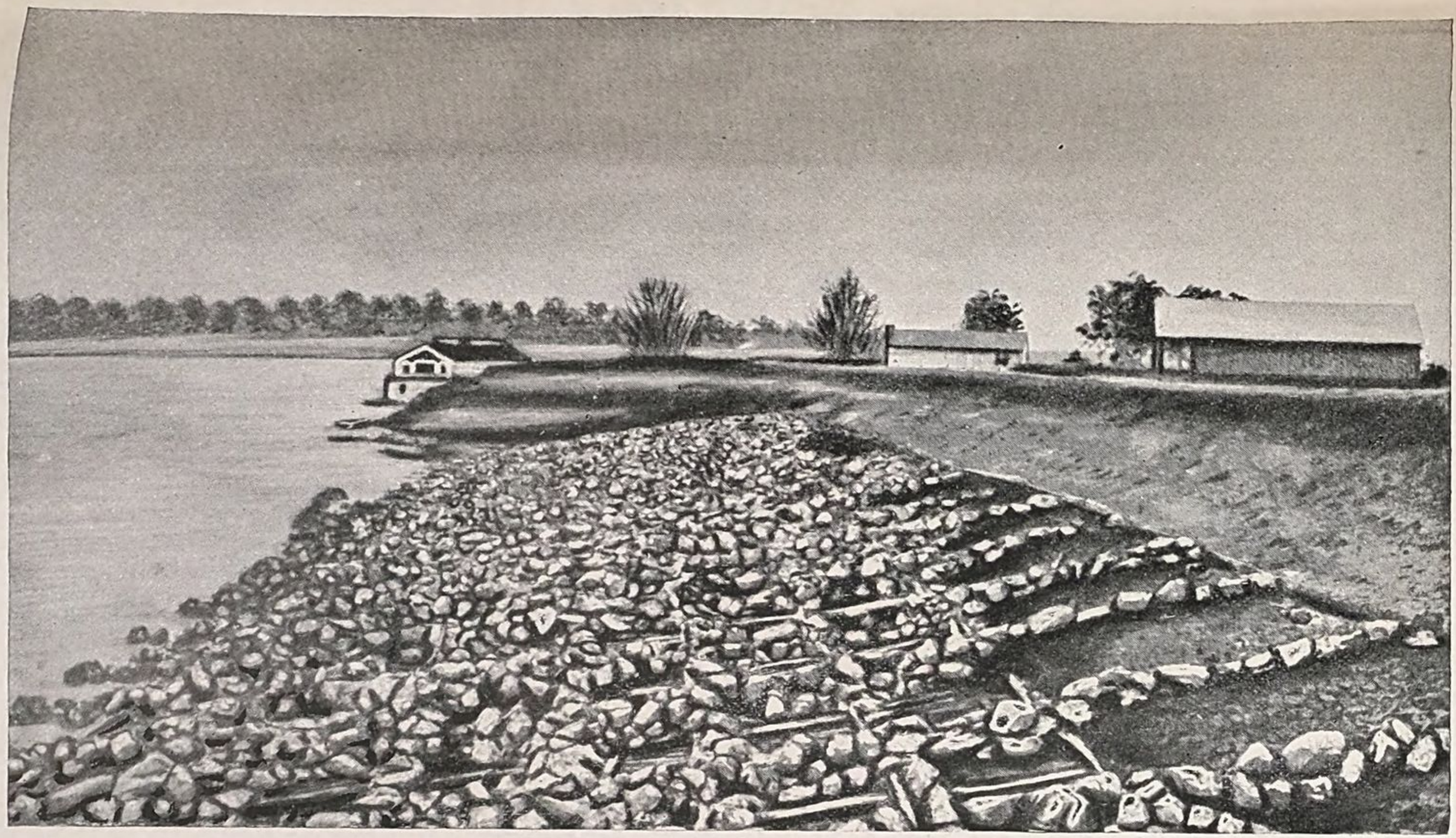
low-water line and the crest of the bank was similar to the subaqueous portion but it was constructed in place and was therefore continuous. The whole was anchored and held securely in place by rock. About 42 pounds to the square foot of surface of mat was used; four times as much as was necessary to sink a mat to the bottom. The dam was built up of layers of mattresses like those in the sill. These mats were so proportioned as to give to the dam when completed side slopes of one on three and a width of crown of 30 feet. On the top of each layer of mats when sunk a quantity of stiff blue clay was spread, in order that it might fill the spaces between the willows and make the dam tight. An extra quantity of rock was placed on the top mat for greater security. These two dams have withstood the unprecedented flood of this year, and as far as can be ascertained at the present high stage of the river they are uninjured. But owing to the fact that the clear waterway at the extreme flood stage over the top of Dam No. 3 was less than over No. 1, the fall was concentrated at this place, and the velocity of the current became so great as to be a serious obstacle to navigation. The mean area of cross-section of the river near Simmesport is about 60,000 square feet. The area over the top of Dam No. 1 is reduced to about 50,000 square feet; that over No. 3 is but 41,000. This is the reverse of what it should be. The areas over the dams should increase from the upper to the lower ones, in order that the fall may be uniformly distributed over them all. This is the case now for low stages of the river; for example, the area over No. 1 at zero of the guage is 4,471 square feet, while over No. 3 it is 5,430. But this could be effected for the flood-stage only by a further contraction at No. 1, or else by moving back the levees and otherwise enlarging the natural section at No. 3. The former method will be the proper one, but it would have been imprudent to have made the entire contraction at the time the dam was built, for it was the first one, and the entire concentration of all at a single point would have produced a velocity that would certainly have interfered with navigation and might have endangered the dam itself.

The flood area over No. 3 is still too large, if the discharge is to be limited to the high-water discharge of Red River, say 200,000 cubic feet a second. When the entire system is completed the areas of flood discharge can be properly adjusted by groins constructed on the sills between high and low water. During the present high water the discharge down the Atchafalaya between levees was 414,281 cubic feet per second at 45.15 on the Simmsport gauge, and afterwards when the crevasses below Simmsport became larger, thus allowing more water to leave the channel, the discharge increased to 480,708, with a gauge height of 44.45. This caused a mean velocity of 7.476 feet per second in a section of 64.301 square feet. Over Dam No. 3 the mean velocity must have been about 11.7 feet per second.

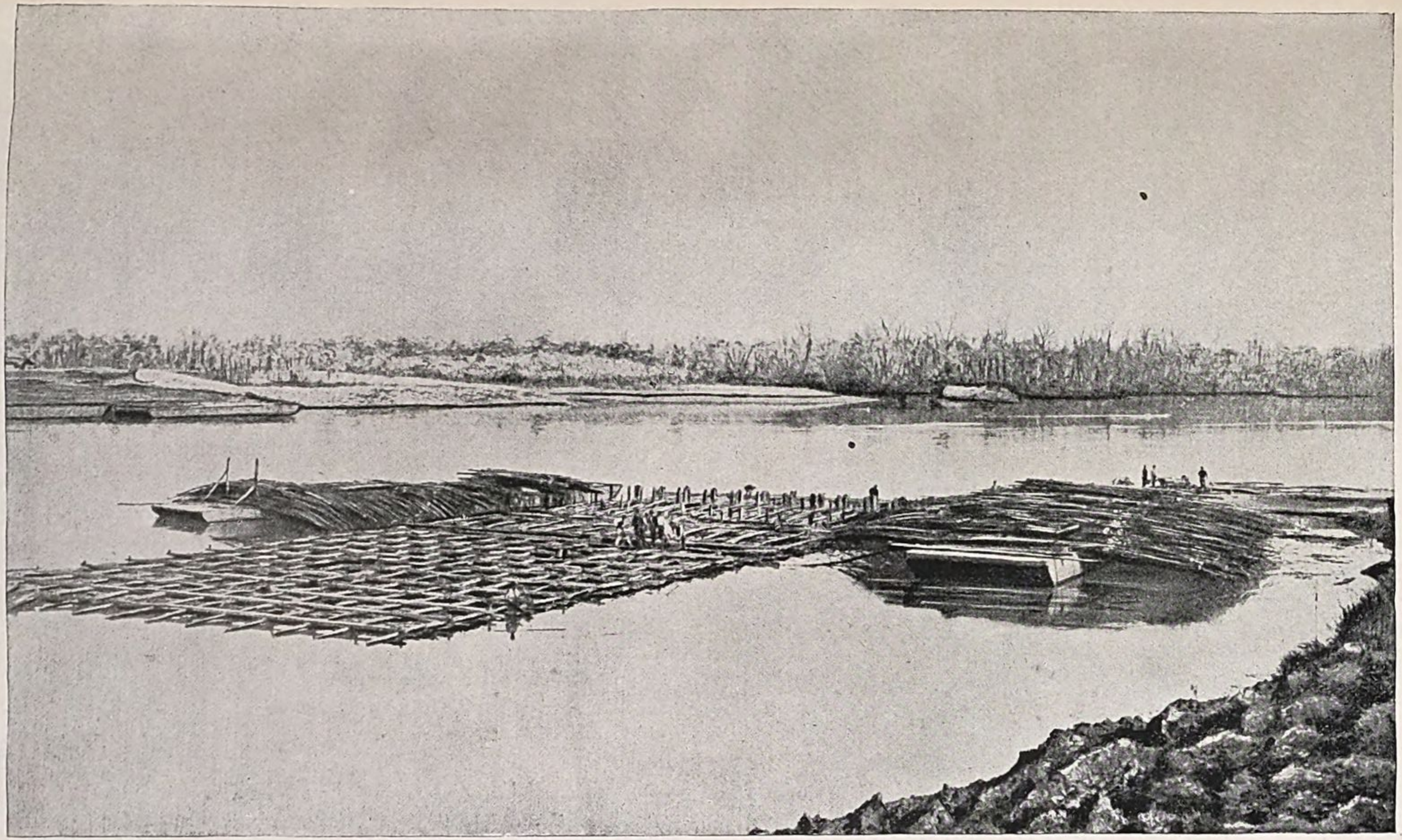
The Atchafalaya problem is influenced greatly by the question of overflow into the Tensas Basin. If the levees in Arkansas and North Louisiana are so built and maintained as to prevent overflow in this basin, then the Atchafalaya will never be overtaxed. On March 6, 1890, the Atchafalaya was discharging past Simmsport 220,599 cubic feet a second, with a gauge height at Barbre's Landing of 42.3 feet. At Red River Landing in the Mississippi the gauge was reading 43.0 feet. This was with all the levees intact. On the 23d of April, when the effect of the return crevasse water from the Tensas was at its height, and before the river was lowered by the large number of crevasses that occurred about this time, Barbre's gauge read 49.7 and Red River Landing 48.77 (the highest ever known). Therefore, since the zero of the former gauge is 0.3 above that of the latter, the water-surface at Barbre's was due to this crevasse water, at least $1\frac{3}{10}$ feet higher this year than it could possibly have been if the Tensas levees had been perfect. This $1\frac{3}{10}$ feet was the "last straw"; without it the Atchafalaya and Bayou des Glaizes levees could have been held, imperfect as they were, and the works at Simmsport would have fulfilled their purpose of limiting the discharge of the Atchafalaya, which, flanked as they were on both sides by crevasses, they can hardly be said to have done.

THE RED RIVER DAM.

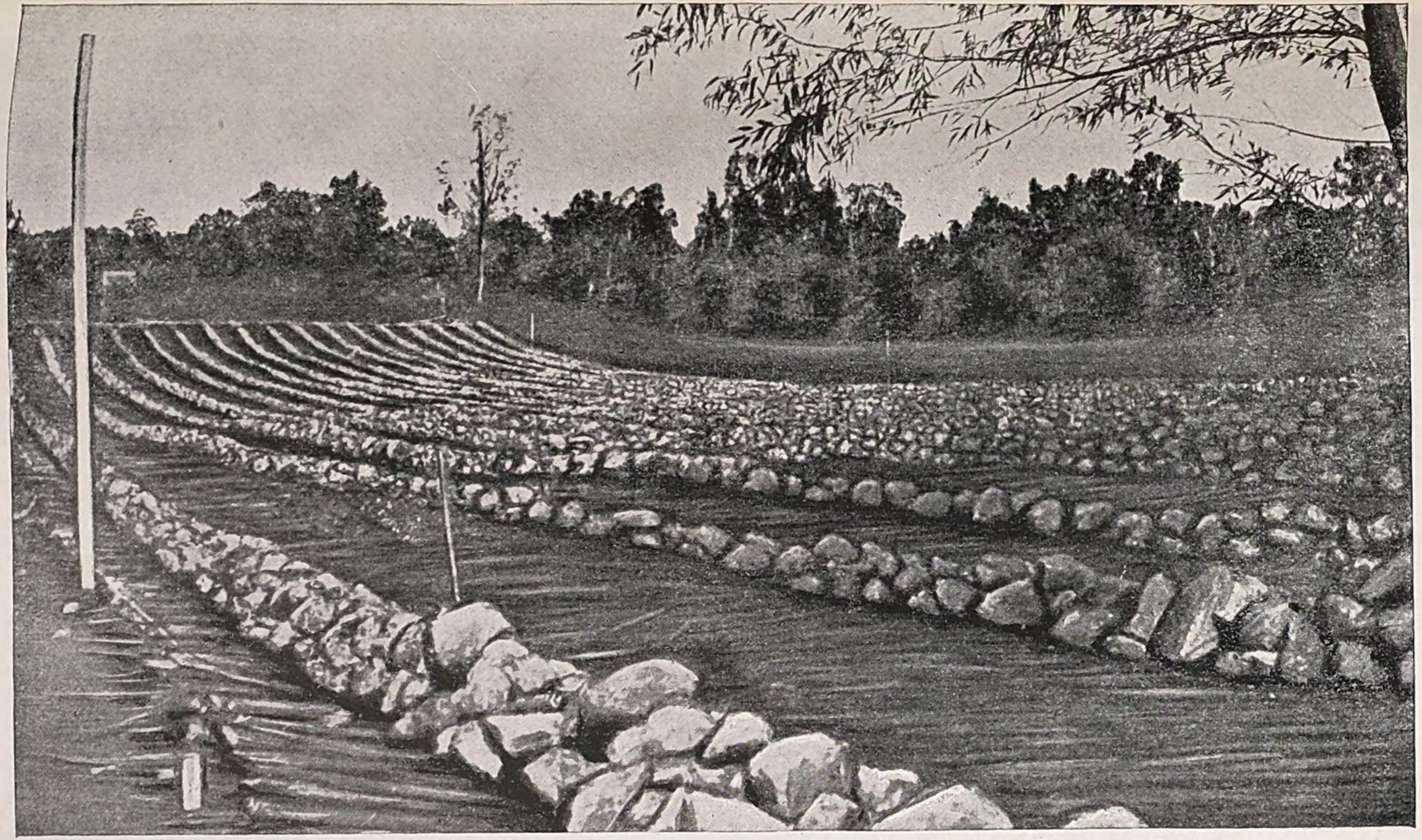
In pursuance of the approved project the sill for this dam has been built. It crosses Old River at a point about three-quarters of a mile below the Sugar-house Chute, upon the line approved by the Commission. The foundation as disclosed by a number of borings is a fairly good one, being composed of river sand interspersed with layers of red and blue clay. The sill was similar in construction to those in the Atchafalaya. It is a good piece of work and was well and cheaply done. The details of its construction are fully set forth in the report of Assistant Engineer Price, which is transmitted herewith. A slight departure from the project was made in the manner of placing the rock on the shore protection and on the sill where it crosses the bed of the slough. Instead of being uniformly distributed over the willow foundation, it was piled in parallel rows running lengthwise of the sill. These rows were about 12 feet apart from center to center, and were about 2 feet high. The idea was that these rows or walls would cause a considerable deposit of silt between them,



SILL NO. 3, ATCHAFALAYA RIVER, SHOWING BANK PROTECTION.



SILL NO. 3, ATCHAFALAYA RIVER: THE CONSTRUCTION OF A MATTRESS. SILL NO. 1 IN BACKGROUND.



RED RIVER DAM, SHOWING THE ARRANGEMENT OF THE ROCK WHERE THE SILL CROSSES THE BED OF THE SLOUGH.

thus completely burying the willows, and that the ridges of rock would then be better able to resist the action of the current than a comparatively thin continuous layer. The river has not yet fallen enough to show how far this expectation has been realized. Of course such a structure is not relied upon to resist the overfall at the dam. The apron there is a strong mattress 3 feet thick, and is eventually to be covered with a layer of rock in pieces of from 1 to 2 tons weight.

MAINTAINING A NAVIGABLE CHANNEL THROUGH LOWER OLD RIVER.

The low-water season was of short duration. The Red River Landing gauge registered less than 12 feet from the 2d of September until the 18th of November, and less than 6 feet from the 17th of October till the 13th of November. The lowest reading on this gauge was 2.40 on November 5, on which day the Barbre's gauge recorded 2.50, the least reading there also. The conditions on the whole were not very unfavorable. The principal reliance was placed upon the dredge for maintaining a channel. It was caused to work mainly upon the mud-lumps and ridges that are found at intervals in the bed of Old River and which acted as dams. As these were cut away the current was able to move the sand into the deep holes, and in this way a much greater quantity of material was gotten rid of than was actually moved by the dredge. The dredge itself gave good satisfaction, and although much interfered with by passing boats it did its work at a moderate cost. I had much difficulty in the first place in getting a crew that understood it and could operate it.

Navigation was not entirely suspended in Old River at any time during the year, but for a few days in the latter part of October and the beginning of November, before the dredge had moved the mud-lumps at Ash Cabin, it was practical for small and light-draught boats only. Navigation was completely restored at a lower stage than for many years, thus indicating that the dredge is the most efficient as well as the cheapest means of fighting low water at this place.

IMPROVING MISSISSIPPI RIVER (NO LIMIT).

Money statement.

Rectification of Red and Atchafalaya rivers:

July 1, 1889, amount available		$86,065.97
Amount disallowed by Chief of Engineers (overpayment)		.10
		86,066.07
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$62,334.44	
July 1, 1890, outstanding liabilities	5.02	
		62,339.46
July 1, 1890, balance available		23,726.61
Amount (estimated) required for completion of existing project		650,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		350,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

SURVEYS, EXAMINATIONS, AND INSPECTIONS.

Since my last annual report was submitted surveys have been made in the caving bends of the river near Lake St. Joseph, Lake Bruin, and Lake St. John. The ends of all these lakes are crossed by very large dikes, and if the river should cave in far enough to destroy these dikes it would be impossible to replace them by parallel lines in the rear, and it would be necessary to abandon many miles of the present levee and construct an entirely new line passing to the westward of all these lakes and throwing out a large number of fine plantations as well as greatly increasing the high-water width of the river.

At Lake St. Joseph it was found that the caving extended down-stream from the head of the lake for a distance of about 7,000 feet and up-stream for a distance of about 10,000 feet, a total length of caving bank of about 17,000 feet. In comparing this survey with the survey of 1882 it is found that the maximum recession of bank below the lake is about 700 feet, the minimum about 550 feet, and the average about 600 feet. Above the lake these numbers are 800, 475, and 600, respectively, making an average annual loss of bank near the lake about 100 feet; 10,000 feet above the lake and extending up-stream for a distance of 7,000 feet farther, the caving has been very irregular and very much greater in quantity. In places it amounted to as much as 2,100 feet. If this rapid caving works down the bend it may involve the levee,

but if it does not the levee may be considered safe for some time to come, for it is 2,000 feet from the river-bank at present.

At Lake Bruin it appears that the caving bank is about 17,000 feet, and, as compared with the survey of 1882, shows a recession opposite the lake of 1,800 feet, which diminishes to 200 feet 5,000 feet below. The maximum recession is 2,900 feet and is found at a point about 4,000 feet above the lake end. Caving diminishes to 200 feet 12,000 feet above the lake. This would give a maximum recession of bank line of over 400 feet per year, and as the levee is only 1,250 feet from the river, it would seem likely that this levee can only last three years longer.

At Lake St. John the caving extends from Hole-in-the-Wall to a point about 25,000 feet below. A comparison with the Mississippi River Commission survey of 1885 shows a maximum recession of the bank line of 700 feet, at a point 6,000 feet above the lake end. From Hole-in-the-Wall Landing to Lake St. John, for a distance of about 17,000 feet, the maximum caving is 700 feet, minimum 200 feet, and the average 500 feet. In front of Lake St. John the caving amounts to only 200 feet, and it does not exceed this amount at any point for 8,000 feet below. The present river-bank is 800 feet from the levee across the head of the lake. The nearest point of the river-bank to any portion of this levee line where a break would do serious harm is 450 feet, and this is about one-half a mile above Lake St. John.

During the month of October, 1889, a survey was made of the Morganza Reach for the purpose of comparison with previous surveys. It may be stated that the survey that was made in 1886, at the time the crevasse was closed, showed that there had been a loss of effective area of cross-section of the river in the vicinity of the crevasse of over 25 per cent since 1883. A survey made a year after the crevasse was closed, in the fall of 1887, showed an increase of area of cross-section at the same points of as much as 12½ per cent. The survey just referred to showed little or no change in the river channel since 1887. This may be readily accounted for by the fact that there had been no very high water between these two dates; in fact the water had not been high enough at any time to cause the levee to produce any marked effect on the regimen of the river. In addition to those surveys others have been made to determine the discharge of the crevasses, but these have elsewhere been reported.

GAUGES.

The gauge service in the fourth district of the Mississippi River has been well maintained throughout the year, and the results, as reported from time to time, may be regarded as reliable. By request of the secretary of the Mississippi River Commission I caused a large number of circulars to be distributed to reliable persons in my district, requesting them to mark in suitable manner the highest point reached by the flood. These circulars were distributed to persons living about 5 miles apart, as near as was practicable, along the river, and these persons were requested to report the results of their observations to the secretary. I have therefore no means of knowing how well they performed their duty. From Mr. Perrilliat, of the Louisiana State board of engineers, I learn that the flood at New Texas Landing was 1.9 feet above that of 1882. Opposite Bayou Sara it was 1.59 feet; at Waterloo, 1.22 feet, and at Hermitage, 1.78 feet. I believe these results to be reliable.

DISCHARGE OBSERVATIONS.

I had not intended in my district to do more during the present year than to secure discharge observations at the time of maximum flood height, but when the flood promised to be an exceptionally large one I endeavored to procure as complete a set of observations as was possible. A good set of observations was obtained at Carrollton, covering the entire period of extreme high water. A fairly good set was obtained at the mouth of Red River, but, as stated elsewhere, the number of observations were not sufficient in the early part of March to fully delineate the discharge curve. Isolated observations were obtained at Warrenton, Natchez, and Baton Rouge. The results of all these measurements are transmitted herewith. Observations were also taken at Simmsport, on the Atchafalaya River. In speaking of these results as fairly good I do not mean to imply that the observations themselves were not trustworthy. They were all carefully taken by competent men and with the very best appliances. The fault with them was that they were not frequent enough. But this was unavoidable and due to the fact that I was obliged to detach most of my men during the extreme high water and make use of their services in the more important work of protecting levees. The discharge observations therefore were necessarily taken at odd times, when the services of the observers could be spared for this purpose.

The greatest discharge observed at Red River Landing was 1,487,362 cubic feet per second; this on the 7th of May. On the same day the discharge in the Atchafalaya River between the levees was 474,225 cubic feet per second. The escape at this time through two crevasses at Barbre's and Ferguson amounted to about 20,000 cubic feet

per second, and the escape through the crevasses in the levee of Bayou Des Glaize, which water was not measured in the Atchafalaya section, amounted to about 50,000 cubic feet per second at the same time. This would make the maximum discharge down the valley on a line drawn through Red River Landing to be about 2,021,617 cubic feet per second. This I believe to have been the greatest discharge as nearly as it is possible to determine it.

Discharge observations.

WARRENTON, MISSISSIPPI.

Date.	Area.	Mean velocity per second.	Discharge per second.	Area of overflow.	Velocity of overflow.	Discharge of overflow.	Vicksburg gauge.
1890.	*Sq. feet.*	*Feet.*	*Cubic feet.*				
Mar. 4	196,370	6.373	1,251,490	1,250	1.835	2,294	46.3
5	196,402	6.368	1,251,659	1,330	1.77	2,354	46.4
6	196,651	6.399	1,257,495	1,330	1.82	2,421	46.4
7	197,444	6.403	1,264,288	1,420	1.85	2,627	46.5
Apr. 11	206,567	6.417	1,325,568	1,760	1.86	3,273	47.5
12	207,267	6.536	1,354,725	1,920	1.86	3,611	47.7

NATCHEZ, MISSISSIPPI.

Date.	Area.	Mean velocity.	Discharge.	Gauge.
1890.				
Mar. 17, a. m	147,104	9.3953	1,382,089	46.65
17, p. m	147,104	9.4932	1,396,492	46.60

RED RIVER LANDING, LOUISIANA.

1890.				
Feb. 21	193,188	5.3468	1,032,939	41.78
22	196,942	5.3556	1,054,757	41.79
23	196,068	5.2951	1,038,199	41.84
24	195,374	5.3019	1,035,856	41.90
26	198,613	5.2542	1,043,557	42.27
27	197,264	5.265	1,038,606	42.39
28	197,938	5.338	1,056,593	42.58
Mar. 3	201,491	5.2762	1,063,111	42.77
18	209,042	6.0084	1,256,018	45.00
28	213,858	5.344	1,142,876	44.85
Apr. 1	215,574	5.3708	1,157,810	45.00
8	218,087	5.5322	1,206,519	46.05
12	219,019	5.6727	1,242,440	46.87
16	226,701	5.6674	1,284,801	47.56
18	230,752	5.6675	1,307,790	48.00
May 1	241,353	6.251	1,456,078	47.51
7	240,864	6.1751	1,487,362	47.29
10	242,000	5.754	1,392,403	47.00
13	235,849	5.832	1,375,630	46.75
15	240,794	5.719	1,377,169	46.61
20	229,018	5.812	1,331,105	46.10

SIMMESPORT, LOUISIANA.

1890.				
Mar. 6	50,492	4.365	220,399	40.30
19	54,393	5.0537	274,886	42.92
27	53,695	5.0057	268,783	42.95
Apr. 7	57,414	5.4285	311,675	44.25
10	58,302	5.8658	341,987	44.80
11	61,874	6.328	391,536	44.90
15	60,420	6.7855	409,982	44.90
17	60,162	6.886	414,281	45.15
May 6	63,238	7.4967	474,057	44.85
8	63,515	7.47	474,454	44.7
12	64,301	7.476	480,708	44.45
14	63,671	7.255	461,968	44.31
17	62,228	7.177	446,638	44.13
19	63,018	7.118	448,554	44.00

Discharge observations.—Continued.

BATON ROUGE, LOUISIANA.

Date.	Area.	Mean velocity.	Discharge.	Gauge.
1890.				
Apr. 26	199,284	6.679	1,331,024	35.3

DONALDSONVILLE, LOUISIANA.

In Bayou La Fourche.

1890.				
Feb. 21	5,098	6.29	31,963	23.64

CARROLLTON, LOUISIANA.

1890.				
Mar. 3	179,383	6.489	1,164,196	14.95
4	179,574	6.238	1,120,179	14.90
5	181,222	6.387	1,157,516	15.05
6	175,746	6.592	1,158,466	15.25
7	175,754	6.438	1,131,565	15.25
8	174,170	6.714	1,169,491	15.25
10	186,755	6.840	1,277,422	15.40
11	185,708	6.190	1,149,656	15.40
12	185,009	6.261	1,158,402	15.40
14	187,197	6.839	1,280,276	15.95
18	186,839	6.434	1,202,273	15.90
19	186,064	6.653	1,237,840	15.85
20	190,905	6.736	1,286,008	15.90
21	192,170	6.257	1,202,325	15.90
22	188,839	6.517	1,130,620	15.90
24	192,549	5.997	1,154,838	15.60
25	191,291	6.123	1,171,345	15.50
26	189,060	6.230	1,177,612	15.40
28	184,617	6.024	1,112,062	15.50
29	181,408	5.967	1,082,502	15.20
31	182,565	5.958	1,087,733	15.15
Apr. 1	181,119	5.663	1,025,654	15.10
2	179,903	6.296	1,132,643	15.25
3	180,639	6.116	1,104,748	15.55
4	179,266	6.029	1,080,950	15.35
5	182,045	6.033	1,108,227	15.30
7	182,444	6.039	1,101,892	15.30
8	182,068	6.027	1,097,423	15.20
9	179,134	5.997	1,074,370	15.20
10	179,598	5.929	1,064,862	15.10
11	178,851	5.715	1,032,245	15.05
12	180,015	5.788	1,042,007	14.95
14	179,789	5.718	1,028,236	15.05
15	180,033	5.732	1,032,006	14.95
16	181,543	5.601	1,016,744	15.05
28	182,165	5.536	1,008,468	14.00
29	181,180	5.473	991,551	14.00
30	180,572	5.437	981,756	13.95
May 1	179,328	5.527	991,156	13.80
6	177,634	5.264	937,133	13.70
14	179,586	5.213	936,175	13.45

IMPROVING MISSISSIPPI RIVER (NO LIMIT).

Money statement.

Surveys, examinations, and inspections:		
July 1, 1889, amount available		$594.44
Amount allotted from act of August 11, 1888, March 20, 1890		3,000.00
		3.594.44
July 1, 1890, amount expended during fiscal year exclusive of liabilities outstanding July 1, 1889	$2,087.03	
July 1, 1890, outstanding liabilities	.51	
		2,087.54
July 1, 1890, balance available		1,506.90
Gauges, fourth district:		
July 1, 1889, amount available		1,125.22
July 1, 1890, amount expended during fiscal year exclusive of outstanding liabilities July 1, 1889		725.20
July 1, 1890, balance available		400.02
Discharge observations:		
July 1, 1889, amount available		2,460.41
July 1, 1890, amount expended during fiscal year exclusive of liabilities outstanding July 1, 1889		2,460.41

IMPROVEMENT OF THE MISSISSIPPI RIVER AT NATCHEZ AND VIDALIA, MISSISSIPPI AND LOUISIANA.

No work has been done in this vicinity, owing to the lack of funds.

The approved project contemplates the protection of the caving banks, by means of submerged sloping spurs, placed at intervals yet to be determined, but which are assumed for the sake of estimate to be about 1,000 feet; the estimated cost of this work is $600,000.

To prevent the flow of water across the neck of land between Giles and Cowpen bends, and the possible destruction of the harbors of Natchez and Vidalia by a cut-off, it is proposed to construct a levee at an estimated cost of $100,000. This makes the total cost $700,000.

Much alarm has been felt by people living at Natchez during the recent high water in regard to this threatened cut-off, which they believe is imminent. It is impossible to make an examination of this locality at present in order to determine how great this danger really is. There is a small balance of about $700 now in hand from former appropriations for this work, which will be utilized when the river falls to a suitable stage in making survey of this locality.

The amount that could be profitably expended upon this work during the fiscal year ending June 30, 1892, is $250,000, which will be used for the purchase of the necessary plant, the construction of the levee, and the commencement of the dike work.

IMPROVING MISSISSIPPI RIVER AT NATCHEZ AND VIDALIA.

Money statement.

July 1, 1889, amount available	$700.65
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	25.00
July 1, 1890, balance available	675.65
Amount (estimated) required for completion of existing project	700,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	250,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

List of civil engineers employed on works of improvement in charge of Capt. Dan C. Kingman, Corps of Engineers, during the fiscal year ending June 30, 1890, under the river and harbor appropriation acts of August, 1886, and August, 1888.

Name and residence.	Time employed.	Compensation.	Where employed.	Work on which employed.
	Mos. Days.	*Per month*		
H. S. Douglas, New Orleans..	9 11	$175	New Orleans.....	New Orleans Harbor.
Do.....	2 19	175	Levees on Tensas Front.	Protection of levees.
W. G. Price, Simmsport, La ..	8 9½	175	Simmsport, La....	Rectification of Red and Atchafalaya rivers.
Do.....	1 22	175	Bayou Plaquemine.	Improving Bayou Plaquemine, Louisiana.
Do.....	1 7	175	Morganza Levee..	Protection of levees.
Do.....	2 1½	175	Simmsport, La....	Discharge observations.
John Ewens, Simmsport, La .	2 23	150	....do	Rectification of Red and Atchafalaya rivers.
Do.....	2 24	150	Bayou Plaquemine.	Improving Bayou Plaquemine, Louisiana.
W. J. Hardee, Point Pleasant, La.	8 5	150	Levees, Tensas Front.	Hard Times-Wilson Levee.
Do.....	1	150	....do	Protection of levees.
Do.....	2	150	Survey, examination, and inspection.	Survey, examination, and inspection.

Approximate value of plant belonging to the United States and used upon the improvement of Mississippi River, fourth district.

Class of property.	Approximate value June 30, 1890.	Class of property.	Approximate value June 30, 1890.
Steamer *General Newton*.....	$13,000	One floating store-house.....	$400
Steam-tug *Comstock*	7,000	Fourteen row-boats	200
Steam-tug *Tilda* (almost totally destroyed by fire May 8, 1890).....	3,000	Tools and appliances	11,000
		Office furniture.....	1,000
Steam-launch *Ruby*.....	3,500	Surveying instruments.....	2,000
Steam-launch *Alaska*.....	3,500	Drawing instruments	200
One dredge-boat (Menge patent)....	10,000	Railway cars and track.....	1,900
Four dump-scows.....	10,000	Miscellaneous: rock, lumber, etc..	28,000
Five quarter-boats	12,000		
Twenty-nine barges	46,500	Total	153,200

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *May* 31, 1890.

CAPTAIN: I have the honor to submit the following report on construction, repair, and protection of levees, Tensas Front, fourth district, from June 1, 1889, to May 31, 1890:

At date of last report but little work was in progress on levees. The Hard Times-Wilson Levee was under construction, being about three-fourths completed. Work was prosecuted until February 7, 1890, when the levee was reported completed. It was inspected and received February 12, 1890. This levee contains the greatest number of cubic yards of earth of any levee yet undertaken by the United States, the contents being 710,163.17 cubic yards, and, including enlargement of old levee, it is 10⅛ miles long. A portion of the levee was built on a ridge between two lakes. This ridge was broken at one point by a bayou or channel connecting the two lakes. This locality was known as the "Gar Hole." The line of embankment crossed this bayou, and some difficulty was anticipated on account of defective foundation into which the levee might sink. To obviate this, however, two side levees were built across the "Gar Hole," inclosing the space for the base of the levee proper. The space was then pumped dry, and the logs, fallen trees, etc., removed. Then two muck ditches were cut, the depth of each being sufficient to reach hard ground. The embankment was then built in the customary way. As it was feared that there would be a bodily sinking of the levee at this point, the earth of which it was built was paid for in excavation instead of in embankment. With this exception there were no unusual features in the construction of the Hard Times-Wilson Levee.

In the latter part of January, 1890, the rapid caving of the river bank at Point Pleasant threatened to breach the levee at that point and flank the Hard Times-Wilson Levee. A piece of new levee was authorized at this place, and its construction commenced in February. But little progress has been made, owing principally to the height of the river which filled the ground with seep water.

During November, December, and January an assistant was sent into the field to run a line of levels over all the United States levees in the district to ascertain positively their condition. The result was generally favorable, the only levees which required any repairs being that portion of the Shipps Bayou to Hard Times Levee crossing the bed of Lake St. Joseph, some portions of Evergreen, and the Kempe Levee.

The work being considered necessary arrangements were made for the requisite tools and labor. Work on Shipps Bayou to Hard Times Levee was commenced February 22 and completed March 27. On Kempe operations were commenced February 24, but have not yet been entirely completed, owing to the high stage of the river, which cut off the supply of earth. On Evergreen nothing has yet been done in the way of permanent repairs.

On February 12, when the final line of levels was run over the Hard Times Wilson Levee the river had risen to 44.8 feet on the Vicksburg gauge, and was against the levee for its full length. Reinforced by heavy rains in the valleys of the Mississippi and Ohio the river continued to rise, and on March 12 had reached 47.4 on the Vicksburg gauge. This properly brings me to a report on the

PROTECTION OF LEVEES DURING HIGH WATER OF 1890.

On March 12, 1890, I received orders from you to proceed from New Orleans to the levees on Tensas Front, for the purpose of holding them, if possible, against the extraordinary flood which was even then straining the line and threatening disaster.

Accordingly, on March 13, I left on the steamer *General Newton* with a barge in tow. The barge was loaded with 50,000 sacks, 50,000 feet of lumber, tarpaulins, chains, twine, nails, etc. On the way up we stopped at the Government fleet near Simmsport where some wheelbarrows and shovels were taken aboard. Although the boat, with a double crew, was run night and day, owing to stormy weather and breaking of machinery we did not arrive on the Tensas Front until the afternoon of March 16.

In going up numerous stops were made for the purpose of ascertaining the condition of the various levees, and if assistance was needed. Word was received that the Point *Pleasant* Levee was in a dangerous condition and sacks were needed. We arrived at *Point* Pleasant on the morning of the 18th, and found a large force at work and the levee temporarily secured.

By this time, owing to the running off of a heavy local rainfall and the breaking of several levees above on the Tensas and Yazoo fronts, the river had commenced to decline. It was known, however, that this decline was but a temporary relief and that the "Yazoo return wave" would have the same effect as in 1884, of putting the river to a much higher stage than the one that had passed.

Knowing this, the most active and energetic work was at once undertaken all along the line. All known weak places were strengthened and arrangements made to concentrate forces and materials at any threatened points.

The line of levees which you assigned to me extended from opposite Warrenton, Miss., to Fairview, La., a distance by the levees of about 125 miles. Of this long stretch there was but a very small proportion that did not require work of some kind for its maintenance, and at times it was impossible for me to get over the line to inspect and direct work as rapidly as I desired.

The river continued to fall until April 2, the total fall at Vicksburg being 1.5 feet, St. Joseph 1.65 feet, and at Natchez 1.5 feet. Another rise from the Ohio, augmented by a rise from the Arkansas, passed the foot of the Yazoo Basin at the time the "return wave" was pouring into the river.

On April 3 the river commenced rising at Vicksburg and continued until it had reached 49.1 feet on April 24, 0.1 foot above the flood of 1884. In general terms it may be said that, so far as the fourth district is concerned, the flood of 1890 culminated on April 23 and 24, at the latter end of a wind-storm of three days' duration. On April 24 the St. Joseph gauge read 45.1 feet, 0.2 foot above 1884, and on April 23 the Natchez gauge 48.6 feet, 1.2 feet above 1884. There were a number of local heights which will be noted later. The extraordinary height attained on April 23 and 24 was owing to the discharge of the tremendous rainfall in the basins of the Big Black, Bayou Pierre, and Cole's Creek, all flowing into the Mississippi between Vicksburg and Natchez.

Between April 22 and 24 nearly all the crevasses on the Tensas Front and Atchafalaya Front occurred, and the rather extraordinary feature of a fall traveling up-stream was noted. On the 24th, at 11.30 a. m., private observers at Natchez reported 4

inches fall; at Hole-in-the-Wall, at 4.30 p. m., 2½ inches; at Kempe, at 6.40 p. m., 1¼ inches; at St. Joseph, at 9 p. m., 1 inch, and no fall at Hard Times or Point Pleasant on the morning of the 25th, if anything a slight rise.

The number of crevasses on the Tensas Front, history, width, depth, and discharge, have already been made the subject of a previous report.

The following is a general description of the work done on the several levees for protection during the flood of 1890, their condition, and such other information as could be obtained:

Bedford Levee.—Head of district; is an ante-bellum levee of strong section. No work was necessary.

Diamond Island Levee.—New levee built by State in 1888–'89, extending from Bedford Levee to Bayou Videl. No work was necessary, but it was guarded by the local authorities.

Bayou Videl Levee.—On west bank of bayou from Diamond Island Levee to Lake Palmyra. No work was done but the levee is generally very scant in section, and was a source of considerable anxiety.

Palmyra Levee.—I have given this name to the long line of embankment extending around the bank of Lake Palmyra from Bayou Videl to Point Pleasant. The greater portion of this line is old levee of very strong section. Some work was necessary in the way of raising at New Carthage, at Woodlawn, and Somerset. A small amount ($106) was expended on this levee for labor by the United States. Some work was done and paid for by the local authorities.

Point Pleasant Levee.—From Lake Palmyra to Hard Times-Wilson. This levee was built and enlarged by the United States in 1882, 1883, 1884, and 1885. It is scant in section at a few places, is generally lacking in height, is full of cray-fish holes, and has decided tendency to slough. It was a constant source of danger, trouble, and expense during the flood. As early as March 15, an extensive slough occurred on the Turner Place. This was secured by the United States at a cost of $1,096. From April 9 to 19, 1,000 sacks were placed on the levee to repair and prevent wave-wash. On April 20, another slough occurred near Bland's store, which was secured and the levee was raised from 1 to 1½ feet for a length of 450 feet. On the night of April 22, the old slough on the Turner Place caved in half way, the crown of the levee and the land slope let down for 50 feet above and 140 feet below, making the slough abont 250 feet in length. The earth used to repair the injury had to be wheeled from 400 to 1,000 feet, the greater portion about 700 feet. Three thousand five hundred sacks were used in addition to earth wheeled in. These sacks were filled about 400 feet from the levee, wheeled onto a flat-boat and boated in front of the slough where they were dumped overboard to form a sort of a retaining-wall for the new earth wheeled in. The cost of this work was $1,148.80, making, with the $1,096 previously mentioned, $2,240.80 expanded on this levee by the United States. On the lower end of the line the levee was raised by the local authorities for a distance of about 2,800 feet. This whole line should be raised, enlarged, and the numerous cray-fish holes repaired. It is far from being safe.

Hard Times-Wilson is a new levee built by the United States and more fully described in the beginning of this report. It extends from Point Pleasant to the United States Shipps Bayou to Hard Times Levee. Although this levee gave considerable trouble, it was to be expected on account of the newness of the embankment, its extent and height. It is only surprising that it did not give away, considering that within a month after its completion it was exposed to such an extraordinary flood. It was nowhere lacking in height and no raising was necessary. The only weakness was sloughing and injury from wave-wash where the fresh earth was exposed. On March 27, a slight slough occurred near the "Gar Hole." It was repaired at a cost of $578.50. This slough recommenced on April 2, and it was again repaired. From April 9 to 19, 2,000 sacks were placed in the levee along Marshall Ridge to repair and prevent wave-wash. From April 18 to 29, the levee sloughed at eight different places and it was only by hard work that a break was prevented. Four of these sloughs occurred in a distance of 1,500 feet. The rains had filled up the swamps on the land side and in some cases it was necessary to wheel in the top of the levee itself. Fortunately the levee had ample height, otherwise this would not have been possible. During the heavy rain of April 21, 22, and 23, the slough near the "Gar Hole" again let go and the top of the levee had to be used to secure it. About 3,000 sacks were used in the same manner as at Point Pleasant. The top of the levee was used to repair the sloughs for a distance of 2,200 feet, the cut being from 1 to 3 feet in depth, this cut leaving 1½ feet of levee above the water at its highest stage. There were a great number of weak points, in addition to those mentioned, but they were not worked on as the danger was not imminent. They should undoubtedly be repaired before another flood. Along the Marshall Ridge where the levee is composed of sand, it has almost been destroyed by rain and wave wash. It is in a very dangerous condition. The 2,200 feet of crown that was wheeled into the sloughs should by all means be replaced.

The cost of the protection work since March 31 was $1,640.50; previous to that date $578.50; total, $2,219.

Shipp's Bayou to Hard Times Levee, or as now known, "Hard Times Levee," was built by the United States in 1882, 1883, 1884, and 1885. About one-half of this line has been thrown out by the construction of the new *Hard Times-Wilson*. The portion now in service connects the latter levee with Evergreen. It crosses the lower end of Lake St. Joseph and is without doubt, from a financial stand-point, the most important levee in the fourth district. It was located by myself in 1882, and is as far back from the river as a practicable crossing of the lake could be found. For a distance of 800 feet this has been a constant source of trouble and expense on account of the embankment settling bodily into the lake bed. Every year since its apparent completion in 1885 it has been raised by the local authorities or by the United States. During the present flood the crown of the levee was only 0.8 foot above the surface. Should a break occur and the usual deep hole be scoured out on the line of the levee it would not be practicable to again dike the lake, and the result would be the abandonment of the Hard Times, Hard Times-Wilson, and Point Pleasant levees, worth in round numbers abont $300,000. In addition to this an entirely new line of levee would have to be built encircling Lake St. Joseph on the west bank and joining the Lake Palmyra Levee in the vicinity of Ashwood. Knowing this, this short piece of heavy levee in the bed of Lake St. Joseph was a source of the greatest solicitude. I believe that the settling still continued and was afraid to place much additional weight on top. All that was done here was to fill and place 200 sacks on the lowest point to prevent the water running over. This cost $32.50. A small slough occurred on the lighter portion of the line out of the lake bed, and this was repaired at a cost of $148.25; total $180.75.

The flood of 1890 exceeded that of 1884 by 0.25 foot at Hard Times Landing; 1884 was 0.5 foot above 1882 at that point.

Evergreen Levee connects Hard Times with Hardscrabble Levee. The major portion of this levee was built by the United States in 1885. It was found to be low at several points, but showed no signs of weakness. During the height of the flood some raising was done by the force engaged on Hardscrabble. No separate account of expenses was kept.

Hardscrabble Levee.—This levee was completed by the United States in 1885, and for its height and section is a remarkably good levee. It was generally overtopped by the flood and was raised by throwing up a narrow ridge of earth and sacks on the edge of the river-crown, for a distance of about 4 miles. As the rain had filled up the swamp, the land crown of the levee is now in very bad shape for about 4 miles, and should be raised and repaired before another flood. The cost of protection was $1,806.77.

Bondurant Levee is a continuation of Hardscrabble and was completed by the United States in 1883. Since that time, owing to the rapid caving of the bank, a new run-around, or horse-shoe, to close some gap has been built almost every year, either by the United States or local authorities. But little of the original Bondurant remains. This levee gave a great deal of trouble, was low, lacking in section, exposed to wave wash, and sloughed badly in two places. Nothing but hard and energetic work and the liberal use of sacks and lumber prevented a break. Prior to my arrival a great amount of work had been done and paid for by the local authorities. The front of the levee had been sacked, the line had been raised, the sloughs repaired, and with a falling river it was secure. The second rise necessitated additional work, which was done and paid for by the United States at a cost of $1,102. Ten thousand feet of lumber and 4,000 sacks were used. A new levee is now being built by the local authorities behind the most dangerous portion.

From Bondurant's to St. Joseph, about 4 miles, is an old levee built many years ago. There were several cray-fish holes and sand boils which were repaired by the local authorities. At the town of St. Joseph the flood of 1890 exceeded that of 1884 by 0.2 foot, and 1882 by 0.6 foot.

From St. Joseph to Kempe, a distance of about 9 miles, there are two large levees, the Marshall and Lee, both of which had to be raised, the latter very extensively. The work was done by the local authorities, the United States furnishing 5,000 sacks.

Kempe Levee.—The existing one is the second built by the United States since 1882, and it is about the heaviest piece of embankment in the district, ranging from 16 to 22 feet in height for a distance of 3 miles. The present levee was completed and received in February, 1889, and, considering its newness, stood the flood remarkably well. The weakness was confined to about 500 feet of the line where the contractors had struck a sand pit and built the embankment of almost pure sharp sand. The levee at this point was about 22 feet high. On March 23, the first signs of weakness were observed. A stream of water of considerable size broke out of the ground about 10 feet from the base of the levee on the land side. A double bulkhead of lumber was built around it and the space between filled in with tamped clay. This eventually showed signs of weakness and the bulkhead was re-enforced with 1,600 sacks. This closed the hole and it gave no further trouble. There was a force at work on this levee

raising it and bringing the crown to a uniform grade. Previous experience on the levee in building it by hired labor had taught me that during high water it was only a matter of a short time when the swamp back of the levee would be deeply overflowed from back water and rain, when no earth could be obtained.

I went to Simmsport and towed up one of the light barges belonging to the United States for the purpose of boating earth from the old levees when the before-mentioned contingency should arise. The barge arrived on the work March 31. Without it I believe the Kempe Levee would have given way. On April 8, while inspecting the the levee, I discovered that the sandy portion was becoming very soft on the land side. April 10, another inspection was made and the softness had increased, small streams of water passing through. Work was absolutely necessary, and operations to strengthen the levee were commenced the following day. My next visit was on Sunday the 13th, when I found no force at work, it not being customary among the negroes to work on Saturday afternoon or Sunday. The danger was imminent, as there was a large portion of the levee that had become semi-liquid and a break was liable to occur at any moment. The citizens up to this time had not appreciated the danger and had not sent their laborers to the work. It became necessary for me to notify them of what was threatened, that a saturated bank of sand was all that stood between them and overflow. After this no further trouble was experienced in securing labor at all times. Long before this the back water had cut off the supply of earth on the land side and all the material used to secure this sandy portion of the levee had to be boated. The source of supply was the tops of old abandoned levees in the vicinity, the barge being pulled through the timber for about half a mile by hand. On April 28 it became necessary to engage a tow-boat and tow the barge 1½ miles up the river in order to get earth. By May 1, the weak point in the new Kempe Levee had been secured, but in the mean while the old Kempe above had commenced to slough, and the barge was transferred to that point and all weak places were repaired. All work was suspended May 8, and the barge was returned to Simmsport. The cost of stopping the hole underneath the levee was $375.65; of securing sandy portion of new levee and sloughs in old levee, $2,930.35. As about 6,615 cubic yards of earth was placed in the levee the cost per cubic yard was 44⅛ cents per yard, which, as all the earth was boated, I consider remarkably cheap. This is the first time within the last twenty years that any of the numerous levees built in the Kempe Bend have ever held an extraordinary flood. The greater portion of the work done has the advantage of being permanent. The raising of the levee should be completed and some little work done on the known weak places at low water to make the line reasonable secure.

At Kempe the flood of 1890 0.31 foot below 1884.

Kempe to L'Argent, about 8 miles, stood the flood without showing any weakness of importance. Some little work was done by the local authorities for precautionary reasons.

At Waterproof the flood of 1890 was 0.6 foot below 1884.

L'Argent to Rifle Point.—This is a general name for about 9 miles of the worst levee in the district, on which more money was spent and more material used than any other place. The local names for the line were in order L'Argent, Aquaska, Monona, Hole-in-the-Wall, Delhi, Canebrake, Shamrock, and Vaucluse, and except Hole-in-the-Wall was built in 1856. It had every element of weakness that I ever heard of in a levee; was too low, lacked base, lacked crown, was exposed to wave wash, riddled with crayfish holes, had large standing trees growing in the slopes, old rotton stumps in the same, sloughed, and was rotton and worthless in every respect. Work for its protection was found necessary as early as January 28 and continued until April 4 under the direction of the fifth Louisiana levee board. On April 5 the United States assumed charge of the line and the greater portion of the work was done and required as the flood reached its height on April 23. The whole line was generally overtopped from 0.5 to 2.5 feet, and was raised principally with sacks, and in several places none of the original levee could be seen, it being entirely covered with sacks. There were thirteen sloughs aggregating 957 feet in length, some of them the most obstinate and dangerous I have ever had to deal with. There were two large dikes on the line, across Bayou L'Argent and the lower end of Lake St. John, and both of them sloughed. At Lake St. John the dike was overtopped 1.5 feet and a crevasse nearly occurred. The seepage water through the levee had overflowed the lands in the vicinity rendering difficult to get earth with which to fill sacks, etc. Large ditches were dug to drain this water off, some of them as much as 1½ miles long. This drainage was of great benefit and assisted materially in the holding of the levee. It would be too tedious to describe all that was done in detail. Work was practically continuous over the whole 9 miles. Over 60,000 sacks were used, 29,750 of which were furnished by the United States and the balance by local authorities. About 4 miles of the levee was overtopped by the flood, in some places as much as 2.5 feet. The hight of the flood at L'Argent exceeded that of 1882 by 2.58 feet and that of 1884 by 1.66 feet. The cost of the work to the United States was $6,684.

Rifle Point Levee from Rifle Point to Grassmere, about 2 miles.—Prior to my arrival some work had been done by the fifth Louisiana levee board in the way of temporarily raising low places. At the height of the flood the levee was overtopped and was raised with earth for one-half mile. A few hundred sacks were used and contributed by the owner of the plantation. The cost of the work was $112.50.

Grassmere Levee connects Rifle Point with the United States Lake Concordia and is about 1 mile long. It is a very old levee and in its time was very strong, having a 20-foot crown. Its present weakness is lack of height. Before my arrival it had been raised temporarily for about 2,000 feet by the fifth Louisiana levee board. This temporary work was afterwards raised and strengthened by the United States. The height to which the levee was overtopped was the thickness of four sacks laid on the flat, or about 1.75 feet. At this locality the flood of 1890 exceeded that of 1882 by 1.9 feet and 1884 by 1.4 feet. The cost of the protection work was $221.90.

Lake Concordia Levee was built by the United States in 1882–'83. It is a long line of generally light embankment encircling Lake Concordia for a distance of about 18 miles. The upper end is at Good Hope Landing and the lower near the town of Vidalia. The flood of 1884 breached this levee at numerous points. These gaps were closed and the line raised about 2 feet and enlarged for about 3 miles by the United States in 1885. This raising and enlarging were afterwards completed by local authorities over the whole line, I believe. The flood of 1890 has proven that it must be still further raised and enlarged to be a reasonably safe levee. Before my arrival protection work had been done by the fifth Louisiana levee board, some 12,400 sacks being used to raise the levee and repair wave-wash. As in the case of L'Argent to Rifle Point, it would be tedious to describe the protection work done in detail. With the exception of one mile on the upper end work was almost continuous. Although the levee was only overtopped for a little over a mile it was awash for three times that distance. There were eight sloughs in the line, aggregating 280 feet in length, and the levee was badly wave-washed for 6½ miles. On April 22 the levee broke about 150 feet from the large crevasse of 1884. The break was one of those accidents that will occur as long as levees exist. No warning was given, and a few minutes before the break occurred persons had passed over the levee and noticed no signs of weakness. Full particulars in reference to this crevasse have been given in a previous report. The cost of the protection work done on this levee was $2,143.70; 16,000 sacks and 30,000 feet of lumber were furnished.

Palto Alto Levee, about one-half mile long, connecting Lake Concordia with the town of Vidalia, required practically no work.

Town of Vidalia Levee, about 1 mile long, is generally a very insignificant affair. In some places there was practically no levee. At the height of the flood the citizens appealed for assistance and 2,000 sacks were furnished them and labor to the extent of about $125.30. The work done was successful. At this point the flood of 1890 exceeded that of 1882 by 0.7 foot and 1884 by 1.1 feet.

Arnauldia Levee, about 1½ miles long, runs from Vidalia to Whitehall. A considerable portion of this levee was fine sand, and after the Concordia Crevasse it was allowed to wash away and cause a crevasse, which, however, was a small affair. The levee was badly exposed to wave-wash, and had been strengthened by facing with sacks for about one-half mile. The cost of this work was $197.50.

Whitehall Levee, about 2 miles long, from Arnauldia to Lucerna. There was a low place, which was raised, at a cost of $4.

Scotland and St. Genevieve Levees, about 2½ miles long, required but little work. Some repairs had been made by the fifth Louisiana levee board prior to my arrival. The United States expended $11.00 in raising two low places that had been previously worked on by the levee board.

Forest, Moro, and Morville Levees, about 4½ miles long. These are all small levees which high water seldom reaches. The protection work done was mostly to prevent wave-wash and raise a few low places. The residents did most of the work and furnished the material. The levee board had done some work prior to my arrival. The United States expended $119 for labor on protection of these levees.

Henderson-Ashley Levee extends from Morville to the United States Greens to Fairview Levee, about 5 miles in length, and is for a considerable distance 15 feet high. It is about thirty years old, and, like most of these old levees, very strong in section. Lack of height is its only weakness, and this, unfortunately, was a fatal one. Prior to my arrival some of the low places had been raised by the levee board. At the top of the flood the line was overtopped an average of 1 foot for a distance of 4 miles. I had had a small levee built on the edge of the river crown of the main levee, and a strong fight was made on this. The Concordia Crevasse demoralized the force, and one of the numerous breaks in the small levee on top was allowed to get too much of a start. The water running over the top of the old levee caused a crevasse which is fully described in a previous report. The cost of the protection work was $513.75. About 8,000 feet B. M. lumber and 4,000 sacks were used, of which 5,500 feet of lumber and 1,500 sacks were furnished by the United States.

Greens to Fair View and Deer Park Levees.—This is practically one line, about 11 miles long, built by the United States. The original Greens to Fairview was completed in 1884, and Deer Park was built in 1888 to close a gap in the main line caused by caving of the river bank. The line, considering its length, required but little work, the principal element of weakness being lack of height. It was extensively overtopped by the flood. Before my arrival work had been done by the levee board. Some rumored dishonest work on the Deer Park Levee had been repaired, and a bad hole underneath the levee on the Fish Pond place had been closed. The upper end of the line passes through cultivated lands, and on this portion there were several incipient sloughs, some wave-wash, and the levee was overtopped for 1½ miles, and was raised with sacks and lumber. The lower end of the line passes through the Glasscock Swamp for a distance of 3½ miles, the embankment ranging from 12 to 17 feet high. It was and is an excellent piece of work, although scarcity of means caused it to be built with small section, the slopes being only 2 and 3 to 1 and the crown 8 feet. At the height of the flood it was overtopped for over a mile, and was raised by building up the edge of the river crown, using the edge of the land crown for that purpose. At the lower end in the Fairview field the levee was washed considerably by the waves, and should be repaired before another flood. The crown in the Glasscock Swamp will have to be repaired and this portion of the line should be cleared of the dense growth of timber which has grown up on the slopes of the levee. In the open fields above the levee should be raised where low. An entirely new levee will be necessary at Deer Park, as the present line will cave in when the river falls. The cost of the protection work was $572.32. Four thousand feet B. M. lumber and 2,500 sacks were furnished by the United States. No accurate data as to the comparative height of the flood of 1890 were obtainable, but it is claimed to have been 1.66 feet higher than 1882. I believe this to be nearly correct, as the established grade of the levee was only 1 foot above 1882.

Fairview is practically the lower end of the levee system on the Tensas Front. The levee board have continued the system about 2 miles farther, and below that there are gaps, private levees or isolated pieces of old public levees.

The term "slough" has been frequently used in this report in describing a certain kind of weakness in some of the levees. A slough is the giving away of the land slope of the levee, caused by the saturation of the embankment or its foundation, or perhaps both. The first indication of a slough is generally small streams of water running through the levee. Next a crack commences to open on the slope, and a large semicircular mass of earth slips down, leaving the slope nearly vertical. Sloughing is progressive, and if something is not done it eventually goes through the levee and a crevasse is made. The method used in cases of this kind was really nothing more than to build the levee out towards the river faster than the slough progressed from the land side. In some cases plain earth was wheeled in; in others sacks were used, and sometimes both, the sacks being placed so as to form a retaining-wall and foundation for the earth. In one case, Point Pleasant, nearly all of the original levee has sloughed away and a new levee built on the river side as described. There is a theory that in dumping loose earth on the river slope it has the same result, and answers the same purpose as putting sawdust under a leaky barge—that is, of stopping the leaks. However true this may be, none of the sloughs that came under my observation were secured until virtually a new levee had been built in front.

Where it was necessary to raise a levee with sacks the method used by me was to place the sacks end to end and slightly lapping each other, parallel with the line of the levee. If necessary this was re-enforced in the rear by a second line, breaking joints with the first. If a second tier in height was required they were laid in the same way, very much in the style of a brick wall, only there were no headers. Laid in this way, with some earth scattered between by way of mortar, they seldom leaked.

I think that so far as the fourth district is concerned the flood of 1890 may be considered the most extraordinary of which we have any record. At such points as it did not exceed in height it exceeded in duration. At Vicksburg tradition makes the flood of 1862 considerably higher than that of 1890, but as the latter flood went above the danger-line on January 30, and on May 31 it is still above it, a period of 121 days, I think 1890 certainly exceeds in duration.

Starting on January 30, when the river reached 41 feet on the Vicksburg gauge, I have compiled the following data, showing duration of flood:

Above 41 feet, 121 days, and is still above; above 42 feet, 119 days, February 1 to May 30; above 43 feet, 112 days, February 4 to May 26; above 44 feet, 105 days, February 8 to May 23; above 45 feet, 96 days, February 14 to May 20; above 46 feet, 81 days, February 26 to May 17, above 47 feet, 50 days, March 11 to March 24, April 7 to May 12; above 48 feet, 22 days, April 15 to May 6; above 49 feet, 3 days, April 24 to April 26.

At Natchez the flood of 1890 on April 23 reached 48.60. The highest flood previously recorded was in 1815, when the gauge reached the same height. As it is scarcely

probable that there was anything approaching a line of levees in 1815, it does not appear reasonable to believe that the levees have raised the flood at this point.

As previously stated, the line which you assigned to me was 125 miles long, and in this stretch, according to the general impression, there are some of the worst levees to hold against a flood that are to be found anywhere on the Mississippi River. Considering the magnitude of the flood, it is gratifying to report that but three crevasses occurred in the distance of 125 miles, and one of these of no importance. The aggregate width of all three was 2,165 feet, or less than half a mile.

In conclusion I would state that while the employés of the Government did all they could, their efforts would have been of no avail had it not been for the energy and public spirit of the residents themselves. If assistance is due to those who help themselves, then these people are fully entitled to all the aid that can be given them.

I left New Orleans March 13 and returned May 15, being absent sixty-three days.

Accompanying this are the reports of Mr. William Garvin, overseer; Mr. V. Maxcy Markoe, inspector, and Mr. L. P. Ault, subinspector.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Capt. DAN. C. KINGMAN,
Corps of Engineers.

REPORT OF MR. WILLIAM GARVIN, OVERSEER.

NEW ORLEANS, LA., *May* 19, 1890.

SIR: I have the honor to report as follows: I arrived at Point Pleasant on April 2 and in accordance with your verbal instructions assumed charge as inspector of the Evergreen, Hard Times-Wilson, and Point Pleasant levees on April 3.

I found a force of men at work repairing slough at the Gar Hole on the Hard Times-Wilson Levee. This place was protected by the usual method; increasing width of levee, building out on river side. At this point it was difficult to obtain earth, the land side being almost entirely submerged by water from White Oak Lake. The material used was mud dug from the bank of the lake and the wheel was a distance of from 400 to 800 feet. To use this material all the timber felled on the right of way had to be cleared off, which added very much to the cost of the work.

From April 9 to 19 about 1,000 sacks were placed on Point Pleasant and 2,000 on Hard Times-Wilson Levee, along Marshall Ridge, to protect them from wave-wash. Along this ridge the levee is built principally of sand and has been badly damaged by rain and wave-wash. In many places the crown is not more than 2 or 3 feet in width and the land side has been washed out to a slope of about 1 to 1.

From April 18 to 29 work was done on eight different sloughs on Hard Times-Wilson Levee, four of them within a distance of 1,500 feet and about 1 mile above Hard Times Landing. For these sufficient earth was found on the lake bank, but it was very wet and difficult to handle. One about 3,000 feet below Gar Hole had lake water at base of levee and I was forced to cut top of levee to protect it. One-half of the crown on the land side was cut 18 inches deep for a distance of about 1,000 feet. For the two about 400 and 900 feet below Gar Hole the earth was taken from the bank of White Oak Lake.

During the heavy rains the old slough at Gar Hole commenced washing and going down very fast and increasing in length. It was covered with old tarpaulins to protect it from rain-wash. All the earth on Lake bank had been used during previous work and the top of levee was taken to protect this place The entire crown was cut from 1 to 3 feet in depth for a distance of about 1,200 feet, letting the levee stand 18 inches above the water at the highest gauge of the river during the present flood. Three thousand sacks were used on this work. They were dumped from a boat at base of levee to act as footing or brace for earth dumped from top of levee.

On April 20 a slough occurred about 400 feet above Bland's Store on Lloyd Place. At this point earth was easily obtained near base of levee.

On April 22 the Point Pleasant levee was raised or topped at four different places from Bland's Store to Turner Place. This work was from 1 foot to 18 inches in height, and all places included about 450 feet in length.

On night of the 22d the old slough on Turner's Place, Point Pleasant Levee, caved in half way; the crown and slope went in for 50 feet above and 140 feet below, making the slough about 250 feet in length. The earth used was wheeled a distance of from 400 to 1,000 feet, the greater portion about 700 feet. Three thousand five hundred sacks were used at this slough; they were filled about 400 feet from levee, wheeled into a boat, then taken to the slough and dumped at base of levee to act as toe for earth.

All sloughs were protected by the usual method, increasing width of levee by

building out on river side and allowing earth to take its natural slope, except at Gar Hole and Turner Place sloughs, where a line of sacks were used as footing or toe for loose earth.

On the Hard Times-Wilson Levee there is a weak place about 3,500 feet below Gar Hole. This place showed signs of sloughing and had several small streams flowing from the base of levee during this flood. During high water this place could not be strengthened without boating earth or using top of levee, which does not exceed 2 feet above the surface at high water.

At the head of the Styx, a deep slough on the Point Pleasant Levee, several considerable streams were flowing through the levee. At the Willow Slough, above Bland's store, there are several bad sand-boils, and the apron crossing the slough has caved in for 8 or 10 feet in width by 40 in length. These places were a source of great anxiety during the present flood. They should be repaired during low water, as it would be very difficult and expensive to repair them properly during a flood.

Very respectfully,

WILLIAM GARVIN,
Overseer.

Mr. H. S. DOUGLAS,
Assistant Engineer.

REPORT OF MR. V. MAXCY MARKOE, INSPECTOR.

NEW ORLEANS, LA., *May* 17, 1890.

SIR: I have the honor to report that on March 13, 1890, a considerable stream of water was discovered coming up out of the ground about 10 feet from the bottom of the slope on the land side of the United States Kempe Levee, supposed to be a crayfish hole. We built a double bulkhead of plank and posts about 3 feet in the clear and 2 feet between the two walls and tamped it with mud. Cost for labor and material, $79.35. It was not strong enough to completely hold the water, and by your orders we re-enforced the outer wall by 1,600 sacks placed like bricks. This accomplished the object at a cost of labor, $296.30. April 10, we discovered that some five consecutive stations at the up-river end of this levee were very weak and that two sloughs had started. As the backwater by this date had entirely submerged the land it was found necessary to get the earth from the abandoned levee about one-half mile toward the river, which we did by hauling a barge by ropes until the levee was stripped to the water's edge. Then it was found necessary to hire a steamer to haul the barge about 1½ miles farther up the river. Cost of steamer, $340. In this way we increased the crown of the levee at these weak places nearly double, with natural slope on the river side, using about 5,590 cubic yards.

In addition we strengthened other small weak places along the old levee above joint with new, using about 1,025 cubic yards. We also placed 865 sacks on three low places. Total cost, $2,930.35, or about 43 cents per cubic yard.

We had much bad weather to contend with, and as hauling the barge through the woods was a slow way the cost looks large even for repair work.

Very respectfully,

V. MAXCY MARKOE.

Mr. H. S. DOUGLAS,
Assistant Engineer.

REPORT OF MR H. P. AULT, INSPECTOR.

CONCORDIA PARISH, LA.

SIR: Pursuant to your instruction I have made a careful tour of the levees in this parish from Bayou L'Argent, the upper boundary, to Fairview, a line of about 65 miles, and herewith submit a report of the work done on same to preserve and protect it during the high water of 1890. In this report I shall speak of the first rise, which took place and reached its maximum height on March 16, 1890, when the gauge read 47 feet at Natchez, Miss.; and the second rise, which reached its highest on April 22, 1890, and the Natchez gauge read 48.60 feet.

The greater bulk of the work was done under and by the instruction of yourself, representing the United States Government, and by Mr. W. F. Ogden and myself, representing the Fifth District Levee Board of Louisiana.

The line of levee known as *L'Argent* to *Rifle Point* was built about the year 1856, except a small portion immediately in front of the "Hole-in-the-wall House," which was built about eight or ten years ago; has never given any trouble, having always been considered perfectly safe until the present flood of 1890. The cause of the

trouble is the Cole's Creek or King's Point cut-off made in 1884, which raised the river level, Mr. Ogden asserts, some 3 feet, and taxed the ingenuity of man to save them.

Work was found necessary on the Monona Levee as early as January 28, 1890, and was kept up continuously until May 1. The levee board used about 10,000 sacks and expended some $1,600 for labor. The United States used about 15,000 sacks, some of which, about 4,000, were paid for by levee board, and no other kind of work was done on this levee, which for its entire distance 1¼ (miles) is completely covered, from its inner to the outer base, with sacks. There were no sloughs, but a number of soft spots occurred, and it was overtopped its entire distance from 6 inches to 2½ feet. It is quite a large levee, having from a 4-foot crown 6 feet high to a 6-foot crown and 9 feet high. The almost entire front is exposed to wave wash, and as this spring has been unusually prolific in storms, work was necessary the entire time, and a few of the storms occurring at night, great vigilance was necessary, and as many as two hundred hands were put to work to hold and save it; in fact its preservation is regarded as something pertaining to the miraculous. A great deal of ditching was done to draw off the seep water with excellent effect.

Hole-in-Wall Levee is 1½ miles long, is a large and well-built dike, being in some places 10 feet high. In March it was seriously affected from wave-wash, and some 5,000 sacks were placed upon it by the levee board. Since the United States took charge considerable work was necessary to preserve it; some 5,000 sacks or more were used to prevent wave-wash. There were three sloughs, 47, 25, and 30 feet, respectively, which took some 1,200 sacks, and for about 250 feet it was overtopped; the length of line worked upon was 1 mile.

Delhi Levee is one-half mile long, between 5 and 6 feet high, and considerably worn. About 500 sacks were used upon it by the levee board during the first rise; afterward and during the second rise it was sacked its entire length, some 1,500 or 2,000 sacks having been used by the United States, it being overtopped.

Canebrake Levee is 1¼ miles long, between 5 and 6 feet high, very old and considerably worn. About 800 sacks were used upon it, revetting the crown in low places. The United States used over 2,000 sacks in revetting the crown, which was overtopped for three-fourths of a mile, and about 600 sacks on two sloughs, 50 and 75 feet long.

Shamrock Levee is 1 mile long, average 6 feet high, old, very much worn and narrow, except a very large dike across the lower end of Lake St. John, which has a 16-foot crown and is about 14 feet high. No work was done on this levee except what was done by the United States; was overtopped for three-fourths of a mile, and a slough of 30 feet in the narrow part, upon which 1,500 or 2,000 sacks were used. The large dike across Lake St. John was overtopped and two fearful sloughs took place, aggregating 150 feet. Not many sacks were used upon this levee. Dirt was hauled in scrapers and about 300 yards of earth placed on the outside.

Vaucluse Levee is 1½ miles long, large, well built, and splendidly preserved; has always been considered one of the safest and best levees in this parish. The levee board spent some $4 during the first rise, but during the second rise while in charge of the United States, two immense and terrible sloughs took place, one 260 feet, the other 190 feet long, and some 8,000 sacks were used in strengthening the outer base, making a most excellent and secure job. These sloughs no doubt were caused by the immense locust trees that grew at the outer base, and whose roots penetrated the levee and acted as conduits for the water.

Rifle Point Levee, next adjoining Vaucluse on the south, is about 2 miles long, very strong, substantial, on very high ground, with an immense batture in front. During the first rise the low places were raised by the levee board, being earthwork entirely, at a cost of about $40. During the second rise it was overtopped for over one-half mile, the labor for which was paid by the United States, and amounted to about $115. Some few hundred sacks were used but they were contributed by the owner of place.

Grassmere Levee comes next, about 1 mile in length, built in ante-bellum days; it is an excellent one, well protected by batture not over 7 feet high. It has, or rather had, a crown some 20 feet broad after the King's Point cut-off was made. It was considered below grade, and the parish raised about one-eighth of a mile of it. When the first rise came it ran over in a few places. To prevent it leaking the levee was ploughed in the center and a levee built on its top for nearly one-half mile at a cost of $30 to the levee board. When the second rise came, this work was kept up, but the water became so high and this temporary levee so soft that 3,500 sacks were used to save it. The sacks were ordered and paid for by the levee board; the labor bill, amounting to $225.90, paid by United States on April 21; night work was done. Seven-eighths of a mile was overtopped.

Next in order comes the United States *Lake Concordia Levee*, some 20 miles in length, commencing at Bullitt's Bayou and running along the front of the following places: Grassmere, Pittsfield, Windermere, Weecama, Claremont, Panola, Helena, Concordia, Fletcher, Sycamore, Minorca, Tacony, Arnauldia, Lake Place, and Palo Alto. This levee was finished by the United States in 1885, I believe, after the parish had spent

some $30,000, and I believe the State levee board had expended quite a sum; is a fine levee in some places, in others narrow; no slope and below grade.

Grassmere.—One mile is in fine condition, and no work was necessary during the present water.

Pittsfield has 3 miles front, is a large fine levee and in good condition, except where it crosses a low place in a slough. In January last I found it full of cray-fish holes and considerable water running through. I dug them out and put in 50 sacks filled with earth, which then closed it, but since the second rise a great quantity of water has run through and for a long while the water was muddy. The heavy black soil of which it was built only saved it. The entire place should be dug out and the levee rebuilt for at least 400 feet. Ten dollars and the 50 sacks paid for by the parish was all the expense incurred during the first rise. During the second rise there was a small slough which 75 sacks stopped and about 200 more were used in wave-washes. The bill, some $22.35, was paid by the United States.

Windermere has 1½ miles of levee in good condition, up to grade. No work was done during first rise. During the second rise a slough occurred 80 feet long in which some 250 sacks were used; paid for by the United States.

Claremont has 1 mile front, some of it in very good condition; the major part is poor narrow crown, not enough slope and lack of height. During the first rise some 1,200 sacks were used, at a cost of $60, paid by the levee board to protect it from wave-wash. During the second rise it was wave-washed a quarter of a mile, overtopped a quarter of a mile, and a slough occurred which took some 100 sacks; altogether 2,000 sacks were used, and all the labor was paid for by the United States.

Panola has a mile front and is in as fully a bad condition as Claremont, both levees being built too near the lake shore and the building for secure protection. During the second rise, as near as I can learn, 4,000 sacks were used, and labor was paid for by the United States. It was wave-washed its entire length and overtopped for three-quarters.

Helena (Ferriday Place) has a mile front, built of light sandy soil, and is a succession of bayous and ridges. While seemingly sound and secure, good high crown and slope, it is the most dangerous levee in the parish, for it gives way without any warning and apparent cause, and is sure to catch you unprepared to meet the emergency. A very large crevasse occurred here in 1884 and very near this place another occurred this year, and in a place that had been ridden over just fifteen minutes before, and which then looked to be sound and in no danger whatever. Just the week previous two bad places were discovered, fortunately in time to save them, one a seep hole, which suddenly enlarged and was with great difficulty stopped. In the other the levee gave down in the center of the crown and a stream of water passed through. One fortunate thing about this crevasse was it giving way where it did. It runs down in the washout of 1884 into Bayou Cocodra; thence through the low center of the parish into Red River, and has done very little injury; in fact, it does not overflow the place upon which it broke, and parties living upon Black River claim that it did not cause the water to rise 1 inch. During the first rise some 500 sacks were used and $40 labor bill paid by the levee board. During the second rise, and up to the time of the crevasse, some 2,500 sacks were used to close breaks in levee above referred to.

Concordia and Fletcher.—Have 1 mile front similar to Ferriday Place, but singular to relate, they have not given any trouble. During the first rise 200 sacks were used and $30 paid for labor and ditching the sea water away by levee board. During the second rise they were overtopped some 300 yards, and 500 sacks were used and the labor paid by the United States.

Sycamore, Minorca, and Tacony have 5½ miles of front, the almost entire length of which is affected by wave-wash, and along this line the battle has been continuous since early in February. The north wind has a 4-mile sweep at it, and the frequent gales this spring from that direction have caused lots of work. During the first rise some 8,000 sacks were used, and $600 expended for labor by the levee board. During the second rise about 10,000 sacks and 35,000 feet of plank were used, and an immense labor bill paid by the United States to protect it from wave-wash and overtop. These levees need raising and width. They had a close call and another rise might get them.

Arnauldia and Lake Place are in excellent form and have required no work.

Palo Alto, or what is known as the Punch Bowls, is about half a mile long; a large, fine levee, reaching 9 feet high; was always regarded as perfectly safe, and no material damage was done to it, as it is a better levee to-day than when it was built. Two sloughs occurred at the maximum of the second rise, about 30 feet long each. It was saved by barrow work, and a complete levee was built on the outside of earth. About 400 sacks that belonged to the town of Vidalia were used on the inside to force out slough with excellent success. The labor bill, $125.30, was paid by the United States.

Town of Vidalia is next with 1 mile front, very high, and comparatively no levee

existed when the water came up, having been worn out and torn almost entirely down, the town having escaped overflow except in the years 1862 and 1882; then it came from the rear. About $300 was spent and 2,500 sacks used by the citizens, who turned out and worked manfully two nights when the levee was expected to give way, which was built entirely of sacks. Two thousand sacks were furnished and $125 labor bill paid by the United States.

Arnauldia adjoins with 1½ miles front. The old levee having caved into the river a new one was built last fall by the levee board, and for some reason unknown no levee was built in front of the residence and quarters, which I had put up at a cost of $125 when the water first came up. When the second rise came the entire line had to be worked upon, some 4,000 sacks and $200 being expended by the United States. When the Ferriday Crevasse occurred they quit work and got their stock over the river into the hills. The levee being neglected gave way and a small crevasse occurred. The water ran down through Whitehall Lake and through the canals into the interior. Only the low lands on three places were submerged; they are now planted in cotton, and the water almost ceased to run through the break.

Whitehall is next with 2 miles of levee front. No work was done, except when the water was at its highest. Four dollars was paid for raising a small portion.

Scotland and St. Genevieve, 2½ miles, high front, except in one or two places. Fifteen dollars was spent by the levee board repairing when the first rise came; afterward the United States spent $11.60 in raising some places.

Forest is next, 2 miles, and has a very high front. Some portions having caved off $25 was spent by the levee board in repairing and afterward $47.50 was paid for labor by the United States to save these places. All the cotton and corn planted on this place was saved.

Moro follows and has a front of 1½ miles and a caving bank. A new levee was built some two years ago, which withstood the present flood. A portion of the old levee remains near the Morville line, which was badly wave-washed, and $19 paid for its repair by the United States. The sacks, some 300, were furnished by the owner of the place.

Morville, 1 mile. Levee quite low and wave-washed; $25 was paid for repairs by levee board. During second rise $52.50 was paid for laborby the United States. All the material used was furnished by the owner of the place.

Wannicut and Henderson-Ashley Levee is next, 5 miles long. It is considered one of the finest levees in this district, and it is beyond comparison the finest in this Parish; is near 15 feet high, with 25 feet crown, and a slope of 1 in 6, but unfortunately is below grade. When the first rise came the entire line was overtopped. Some 7,000 or 8,000 feet of plank, etc., being used, besides 4,000 sacks; also the labor bills, amounting to $500, was paid by the United States. Some 2,500 sacks and a lot of lumber was furnished by the owner of these places. When the Ferriday break occurred the manager was sent off with the stock to the hills, and the levee not getting the attention it should have got, gave way in a number of places, all of which were closed except one, which widened so rapidly that it was impossible to save it, and the water is now running through there 800 feet wide. It is of the lower line of levees, and all of the places below it being already submerged it raised the water inside and will hold the water up on them for a longer period than if it had remained intact.

United States Green's to Fairview consists of Guia Tract, Handy Walton's, Lehman's, Green's, Deer Park, Forest Home, Fish Pond, Ashley, and Glasscock's, about 12 miles long. Guia Tract, Walton's, and Lehman's are part of the old levee, and gave no trouble except at Lehmans, and was overtopped. About 200 sacks were used and labor paid by the United States. No other work was done or necessary.

Greens, one-half mile, in fair condition. Very little work was done on this levee during the first rise. About $15 was paid by parish to repair ruts caused by rains and sinks, and by barrels and boxes being left in the levee by contractors. About 500 sacks were used during the second rise to protect it from wave-wash, which was paid for by the United States.

Deer Park, 1½ miles, is also a fine levee, but I very much fear the greater part of it will cave in when the water falls. But little work was done during the first rise, not over $30 by the levee board for general repairs, but during the second rise 3,000 sacks and 1,500 feet of lumber was used to prevent wave wash and stop two sloughs, each about 20 feet long. The bill for labor and watching paid by the United States amounted to $200.

Forest Home has a mile front; it is in fair condition. During the first rise no money was spent on it. During the second rise it was overtopped its entire length, and 3,000 or 4,000 sacks and 1,000 feet of plank used, and labor bills amounting to $150 paid.

Fish Pond is about half a mile long, high front and small levee. During the first rise a slough occurred in Fish Pond Bayou that cost the levee board $124 to repair for labor and material. During the second rise it was overtopped for about 150 or 200 yards, about 400 sacks being used.

Ashley has a high front 1 mile long, was safe and no work necessary. Glasscock is a fine levee and large, 17 feet high, 8 feet crown; is built through the swamp of that name, and is entirely overgrown with briars, willow, cottonwood, and sycamore. It is very essential for the future preservation of that levee that all of this growth should be cleaned off, so that the sod may have a chance to grow. During the first rise the water did not get to the top, and no money was expended thereon. The second rise overtopped it for over a mile, and the inner crown was sacrificed to make a levee on the outer crown, there being a heavy batture in front. No sacks or other material was used. The bill for labor was $123.75, and was paid by the United States. In the Fairview field where it was exposed to wave action the inner base is badly washed, and must be repaired to make it safe.

In connection with this report I will state that the parish employed watchmen day and night on all dangerous points along the entire front, and have paid out some $700 therefor.

Respectfully submitted.

H. P. AULT,
Inspector.

Mr. H. S. DOUGLAS,
Assistant Engineer.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *May* 31, 1890.

CAPTAIN: I have the honor to submit the following report on the work of improving the harbor at New Orleans, La., from June 1, 1889, to May 31, 1890:

At date of last report, May 31, 1889, the condition of the work was as follows: The work done on spur-dikes in previous years appeared to be in good condition. In Spur No. 1 of the Greenville Bend system 68,500 square feet of mattress and 188,670 cubic feet of crib-work had been placed; material for construction to the value of about $17,000 was on hand. Three new barges and a quarter-boat had been added to the plant, one of the old barges had been rebuilt, and the tug *Tilda* had been equipped with a new boiler. New crib-ways were being built and general preparations for the resumption of spur-dike construction were in progress.

On June 14 and 15, 1889, the tug moved the plant from laying-up quarters to the Greenville Bend. The river at this time was raising rapidly, but it was known that the rise would last but for a short time. The great advantage of commencing at this early date will be seen in this report.

GREENVILLE BEND.

On June 22 the construction of cribs for the completion of Spur No. 1, Greenville Bend, was commenced, and on August 9 the spur was finished. The number of actual working days was thirty-seven, twelve days being lost by Sundays, holidays, rain, and storms. Daily showers and difficulty in handling the brush stored on the bank from the previous season retarded the work. The cribs built and sunk were numbered continuously from those of the previous season, and had the following dimensions:

Crib No. 7	feet	50 by 110 by 6	Crib No. 11	feet	32 by 250 by 6
Crib No. 8	do	44 by 130 by 6	Crib No. 12	do	26 by 280 by 6
Crib No. 9	do	38 by 150 by 6	Crib No. 13	do	26 by 74 by 6
Crib No. 10	do	38 by 24 by 6	Crib No. 14	do	20 by 400 by 6

As the work on this spur covered the whole of one and part of a second season, it would be somewhat confusing to separate the data following, so I have consolidated it for the entire spur.

Cost and material.

3,216.34 cords brush, at $1.68	$5,403.45
194.11 cords poles, first grade, at $3	582.33
14.64 cords poles, second grade, at $2.75	40.26
6,200 feet, B. M., 2 by 4 inch lumber, at $11	68.20
74,016 feet, B. M., 3 by 6 inch lumber, at $10.90	743.83
2,138.75 tons rock, at $2	4,277.50
5,510 pounds galvanized wire, No. 10, at 4 cents	220.40
38 kegs steel wire nails	109.47
16½ kegs wrought spikes	49.05

8 kegs cut nails	$19.15
8,160.48 pounds iron rods, chains, etc., at 3½ cents	285.62
Three kedges, including rock	17.03
Pay-roll, services	11,395.26
Rations, approximated, 3,300, at 30 cents	990.00
Chartered tug	1,040.00
Tug *Tilda* ninety-nine days, at $20	1,980.00
Total	27,224.55

Square feet of mattress in spur	$68,500
Pounds of rock per square foot to sink	13.87
Cost per square foot in place	$0.07¼
Cubic feet of crib-work in spur	447,486
Pounds of rock per cubic foot to sink	7.436
Cost per cubic foot in place	0.04\frac{274}{1000}$
Total time occupied in construction of spur	days.. 123
Sundays and holidays	do... 15
Rain and storm	do... 12
High water and drift	do... 22
Actual working time	do... 74
Maximum length of spur	feet.. 430
Maximum height of spur	do... 60
Maximum depth of water at low water	do... 152

The project estimated the cost of the Greenville Bend spurs at $12,000 each, and as the cost of Spur No. 1 was so greatly in excess of this, some explanation should be made. In the first place the size of the spur and cubical contents are about twice those of any of the spurs built in the Gouldsboro Bend, on which the estimate of $12,000 was based. The temporary disabling of the *Tilda*, the chartering of another tug, and the delay of twenty-two days from high water and drift, during which time a large force had to be retained on the work, added about $3,000 to what the expenses would have been even under favorable circumstances. The great depth of water in which the mattresses and cribs were to be sunk rendered extreme caution necessary, and in work of this character, depending in a great measure for its success on one man, caution means delay.

Notwithstanding all this it will be noted that the cost of mattress-work was less than that determined in the Gouldsboro Bend, and the cost of crib-work was slightly in excess. A careful study of the data given will, I think, afford any additional explanation that may be necessary.

On August 9 work on Spur No. 2, Greenville Bend, was commenced and it was finished September 21. As was the case on Spur No. 1, the plant was not large enough to weave in one piece the foundation mattress required, so an extra or built mattress was necessary. The dimensions of this mattress were 110 by 150 by 1.5 feet thick. It was sunk at the outer end of the spur in 160 feet of water, and was held in place by three wire ropes running to wooden kedges filled with rock.

Cost and material when in place were:

85.37 cords brush, at $1.68	$143.42
4,229 feet, B. M., 2 by 4 inch lumber, at $10.90	46.10
2,196 feet, B. M., 3 by 6 inch lumber, at $10.90	23.94
77.34 tons rock, at $2	154.68
240 pounds galvanized wire No. 10, at 4 cents	9.60
5½ kegs 6-inch steel wire nails, at $2.35	12.92
1½ kegs 9-inch steel wire nails, at $3.33	5.00
700 pounds 2-inch wire rope, at 8½ cents	59.50
Three kedges, including rock	17.00
Pay-roll, services	532.82
Rations, approximated, 200, at 30 cents	60.00
Tug *Tilda* four days, at $20	80.00
Total	1,144.98

Number of square feet in mattress	16,500
Pounds of rock per square foot to sink	9.37
Cost per square foot in place	0.06\frac{24}{100}$

The usual woven mattress was commenced as soon as the built one had been sunk. In place the cost and material were:

285.82 cords brush, at $1.68	$480.18
42 cords poles, first grade, at $3	126.00
9 cords poles, second grade, at $2.75	24.75
322.95 tons rock, at $2	645.90
5,901 pounds iron rods, chains, etc., at 3½ cents	206.54
2,069 pounds galvanized wire No. 10, at 4 cents	82.76
3 kegs 9-inch steel wire nails, at $3.33	10.00
1½ kegs 6-inch steel wire nails, at $2.35	3.52
1 keg 3½-inch steel wire nails, at $3.15	3.15
Pay-roll, services	1,181.58
Rations, approximated, 877, at 30 cents	263.10
Tug *Tilda*, eight days, at $20	160.00
Total	3,187.48
Number of square feet in mattress	44,250
Pounds of rock per square foot to sink	14.6
Cost per square foot in place	$0.07 9/10

Construction of cribs for Spur No. 2 was commenced August 13. The dimensions of the cribs were:

Crib No. 1	feet	56 by 40 by 6	Crib No. 5	feet	32 by 220 by 6
Crib No. 2	do	50 by 80 by 6	Crib No. 6	do	26 by 270 by 6
Crib No. 3	do	44 by 130 by 6	Crib No. 7	do	26 by 110 by 5
Crib No. 4	do	38 by 170 by 6	Crib No. 8	do	20 by 450 by 6

Cost and material were:

1,180.92 cords brush, at $1.68	$1,983.95
101.21 cords poles, first grade, at $3	303.63
1.34 cords poles, second grade, at $2.75	3.69
1,034.93 tons rock, at $2	2,069.86
37,300 feet, B. M., 3 by 6 feet lumber, at $10.90	406.57
1,752 pounds galvanized wire, No. 10, at 4 cents	70.08
20 kegs 9-inch steel wire nails, at $3.33	66.64
2 kegs 6-inch steel wire nails, at $2.35	4.70
Pay-roll, services	4,224.63
Rations, approximated, 2,741, at 30 cents	822.30
Tug *Tilda*, twenty-eight days, at $20	560.00
Total	10,516.05
Number of cubic feet of crib-work in spur	263,180
Pounds of rock per cubic foot to sink	7.88
Cost per cubic foot in place	$0.04
The total cost of the spur was	$14,848.51
Total time to complete	days 40
Sundays and holidays	do 6
Rain	day 1
Out of brush	days 5
Actual working time	do 28

As in the case of Spur No. 1, the cost exceeded the estimate based on the Goulds-borough spurs, although the cost per unit—*i. e.*, square foot of mattress and cubic foot of crib work—was considerably less. It is certain that spur-dikes, as with most other structures, cost in proportion to their size.

The completion of these two spurs in the Greenville Bend finished all work in that locality authorized at present.

THIRD DISTRICT FRONT.

On September 20, 1889, immediately on completion of the spurs in the Greenville Bend, preparations for work in the Third District Bend, in the lower portion of the city, were commenced. These preparations consisted chiefly in loading up the barges with rock and the lumber and other material on hand; moving and mooring the plant at the new locality. The total cost of this, which may be called installation, was $795.61.

The work proposed in the third district front was to consist of four (Nos. 1, 2, 3, and 4) submerged sloping spur-dikes, extending on a slope of three horizontal to one verti-

cal from low-water mark to deep water in the channel of the river. In addition to this, each spur was to be prolonged from the low-water mark back to the main levee by an earthen spur or levee, protected by a covering or pavement of rock, this covering to extend 20 feet above and 50 feet below, to form aprons, and practically prolong the foundation mattress to the main levee. The ultimate result to be a continuous spur commencing above high-water mark instead of at low.

I went onto this work with an organized force of trained employés, was favored with exceptionally fair weather and very low water. The results of this combination are pretty well evidenced in this report.

Construction of Spur No. 1 was commenced September 28. The style of mattress used on this and succeeding spurs was what is known as the "built" mattress, to distinguish it from the former style designated as "woven."

The dimensions of the mattress were 111.6 by 362 by 1.5 feet thick, and the cost and material were:

351.60 cords brush, at $1.68	$590.69
33.91 cords poles, first grade, at $3	101.73
13.98 cords poles, second grade, at $2.75	38.44
12,876 feet, B. M., 2 by 4 inch lumber, at $10.90	140.35
334 tons rock, at $2	668.00
578 pounds galvanized wire, No. 10, at 4 cents	27.12
11 kegs 9-inch steel wire nails	35.65
14 kegs steel wire nails 6-inch	38.42
1 keg 3½ inch steel wire nails	3.10
1,253 pounds iron rods, bolts, etc., at 3½ cents	43.85
Pay-roll, services	1,009.38
Rations, approximated, 650, at 30 cents	195.00
Tug *Tilda*, seven and one-half days, at $20	150.00
Total	3,041.73
Number of square feet in mattress	40,400
Pounds of rock per square foot to sink	16.53
Cost per square foot in place	$0.07 53/100

The dimensions of the cribs built and sunk on this spur were:

Crib No. 1	feet	40 by 90 by 6	Crib No. 3	feet	24 by 234 by 6
Crib No. 2	do	32 by 159 by 6	Crib No. 4	do	16 by 312 by 5

The cost and materials were:

500.93 cords brush, at $1.68	$841.56
22.16 cords poles, first grade, at $3	66.48
17,124 feet, B. M., 3 by 6 inch lumber, at $10.90	186.65
391.05 tons rock, at $2	782.10
660 pounds galvanized wire, No. 10, at 4 cents	26.40
161 pounds iron rods, at 3½ cents	5.63
8 kegs 9-inch steel wire nails	26.65
1 keg 6-inch steel wire nails	2.75
Pay-roll, services	1,381.59
Rations, approximated, 1,469, at 30 cents	440.70
Tug *Tilda*, thirteen days, at $20	260.00
Total	4,020.51
Number of cubic feet of crib-work	115,776
Pounds of rock per cubic foot to sink	6 755/1000
Cost per cubic foot in place	$0.03 47/100
Total cost of the subaqueous portion of the spur was	$7,062.24
Total time to complete, days	24
Sundays, do	3
Actual working time, do	21

On crib construction five days were lost on account of non-delivery of brush.

Construction of Spur No. 2 was commenced October 23. The style of mattress was the same as on Spur No. 1, and its dimensions were 102.75 by 344 by 1.5 feet thick. The cost and material were:

328.64 cords brush, at $1.68	$552.12
19.65 cords poles, first grade, at $3	58.95
11,500 feet, B. M., 2 by 4 inch lumber, at $10.90	125.35
1,000 feet, B. M., 3 by 6 inch lumber, at $10.90	10.90

197.5 tons rock, at $2	$395.00
753 pounds galvanized wire, No. 10, at 4 cents	30.12
12½ kegs 9-inch steel wire nails	41.65
14 kegs 6-inch wire nails	38.42
1 keg 3½ steel wire nails	3.10
1,414 pounds iron rods, at 3½ cents	49.49
56 pounds fish-plates, at 4 cents	2.24
28 bolts ½ by 27 inches, at 15 cents each	4.20
Pay-roll, services	728.16
Rations, approximated, 600, at 30 cents	180.00
Tug *Tilda*, five days, at $20	100.00
Total	2,319.70
Number of square feet in mattress	35,054
Pounds of rock per square foot to sink	11.27
Cost per square foot in place	$0.06 63/100

The dimensions of the cribs built and sunk on this spur were:

Crib No. 1	feet	32 by 115 by 6
Crib No. 2	do	24 by 238 by 6
Crib No. 3	do	16 by 305 by 6

The cost and material were:

361.54 cords brush, at $1.68	$607.39
10.28 cords poles, first grade, at $3	30.84
16.66 cords poles, second grade, at $2.75	45.81
13,350 feet, B. M., 3 by 6 inch lumber, at $10.90	145.51
378.81 tons rock, at $2	757.62
369 pounds galvanized wire, No. 10, at 4 cents	14.76
7 kegs 9-inch steel-wire nails	23.32
1½ kegs 6-inch steel-wire nails	4.12
161 pounds iron rods at 3½ cents	5.63
Pay-roll, services	960.20
Rations (approximated) 600, at 30 cents	180.00
Tug *Tilda*, 7½ days, at $20	150.00
Total	2,925.20
Number of cubic feet of crib-work	90,632
Pounds of rock per cubic foot to sink	8.36
Cost per cubic foot in place	$0.03 23/100

The total cost of the subaqueous portion of the spur was $5,244.90.

Total time to complete	days	20
Sundays	do	3
Rain and storm	do	2
Actual working days	do	15

On crib construction one day was lost from non-delivery of brush.

Construction of Spur No. 3 was commenced November 19, although the last crib on Spur No. 3 had not yet been sunk. The dimensions of the mattress were 102.75 by 344 feet by 1.5 feet thick, and the cost and material were:

271.01 cords brush, at $1.68	$455.30
30 cords poles, first grade, at $3	90.00
12,000 feet, B. M., 2 by 4 inch lumber, at $10.90	130.80
1,000 feet, B. M., 3 by 6 inch lumber, at $10.90	10.90
228.20 tons rock, at $2	456.40
720 pounds galvanized wire, No. 10, at 4 cents	28.80
13 kegs 9-inch steel-wire nails	43.32
19 kegs 6-inch steel-wire nails	52.14
161 pounds 3½-inch steel-wire nails	4.97
1,549 pounds iron rods, bolts, etc., at 3½ cents	45.21
80 pounds fish-plates, at 4 cents	3.20
38 bolts, ½ by 27 inches, at 15 cents each	5.70
Pay-roll, services	754.16
Rations (approximated) 680, at 30 cents	204.00
Tug *Tilda*, 5⅓ days, at $20	106.66
Total	2,400.56

Number of square feet in mattress	35,054
Pounds of rock per square foot to sink	13.02
Cost per square foot in place	0.06\frac{847}{1000}$

The dimensions of the cribs built and sunk on the spur were:

Crib No. 1	feet	32 by 38 by 6	Crib No. 3	feet	24 by 238 by 6
Crib No. 2	do	32 by 38 by 6	Crib No. 4	do	16 by 260 by 6

The cost and material were:

305.81 cords brush, at $1.68	$513.76
25.41 cords poles, first grade, at $3	76.23
21.15 cords poles, second grade, at $2.75	58.16
119.40 feet, B. M., 3 by 6 inch lumber, at $10.90	130.15
305.64 tons rock, at $2	611.28
195 pounds galvanized wire, No. 10, at 4 cents	7.80
172 pounds galvanized wire, No. 8, at 4 cents	6.88
7 kegs 9-inch steel-wire nails	28.32
161 pounds iron rods, at 3½ cents	5.63
Pay-roll, services	1,020.00
Rations (approximated) 450, at 30 cents	135.00
Tug *Tilda*, 6⅚ days, at $20	166.60
Total	2,759.84

Number of cubic feet of crib-work	84,824
Pounds of rock per cubic foot to sink	7.206
Cost per cubic foot in place	0.03\frac{753}{1000}$

The total cost of the subaqueous portion of the spur was $5,160.37.

Total time to complete	days	22
Sundays	do	3
Rain and storm	do	1
Actual working days	do	18

Construction of spur No. 4 was commenced November 29. The dimensions of the foundation mattress were 118 by 322 feet by 1.5 feet thick, and the cost and material were:

286.36 cords brush, at $1.68	$481.08
33.85 cords poles, first grade, at $3	101.55
13,500 feet, B. M., 2 by 4 inch lumber, at $10.90	147.15
2,700 feet, B. M., 3 by 6 inch lumber, at $10.90	29.43
294.39 tons rock, at $2	588.78
755 pounds galvanized wire, No. 10, at 4 cents	30.20
17 kegs 9-inch steel-wire nails	56.65
18 kegs 6-inch steel-wire nails	49.40
85 pounds 3½-inch steel-wire nails	2.65
1,800 pounds iron rods, at 3½ cents	63.00
108 fish-plates, at 7 cents each	7.56
108 bolts, ¾ by 2½ inches, at 5 cents each	5.40
30 bolts, ½ by 27 inches, at 15 cents each	4.50
Pay-roll, services	1,045.29
Rations (approximated) 660, at 30 cents	198.00
Tug *Tilda*, 5⅜ days, at $20	113.33
Total	2,923.97

Number of square feet in mattress	37,996
Pounds of rock used per square foot to sink	15.5
Cost per square foot in place	0.07\frac{695}{1000}$

Owing to the higher stage of the river and swifter current this matress was built considerably stronger than the others. This, together with delays from heavy drift, made it more expensive than the mattress on Spurs 2 and 3.

The dimensions of the cribs built and sunk on Spur 4 were:

Crib No. 1	feet	48 by 92 by 6	Crib No. 4	feet	24 by 260 by 6
Crib No. 2	do	40 by 136 by 6	Crib No. 5	do	16 by 276 by 6
Crib No. 3	do	32 by 186.6 by 6			

The cost and material were:

621.96 cords brush, at $1.68	$1,044.89
79.97 cords poles, first grade, at $3	215.91
24,090 feet, B. M., 3 by 6 inch lumber, at $10.90	262.58
403.80 tons rock, at $2	807.60
823 pounds galvanized wire, No. 10, at 4 cents	32.92
235 pounds galvanized wire, No. 8, at 4 cents	9.40
16 kegs 9-inch steel-wire nails	53.31
1 keg 6-inch steel-wire nails	2.75
215 pounds iron rods, at 3½ cents	7.52
Pay-roll, services	2,513.78
Rations (approximated), 990, at 30 cents	297.00
Tug *Tilda*, 13⅔ days, at $20	273.33
Total	4,520.99
Number of cubic feet of crib-work	161,059
Pounds of rock per cubic foot to sink	4.952
Cost per cubic foot in place	0.02\frac{807}{1000}$

The total cost of the subaqueous portion of the spur was $7,444.90.

Total time to complete	days	35
Sundays and holidays	do	6
Rain and storm	do	1
Actual working days	do	28

During the construction of this spur there was a considerable rise in the river, accompanied by heavy drift. This, together with dense fogs and the holiday season, delayed the work and increased the expense. The work required in the project to complete Spurs 1, 2, 3, and 4 on the third district front, that is the spur levees prolonging the crib-work back to the main levee and above high-water mark, I am compelled to consolidate, as the force engaged was constantly shifted from one spur to another, depending on the supply of material and the necessity of haste on the subaqueous portions of the spurs.

I give a general description of this work. On the center line of each spur an earthen levee with crown of 10 feet and side slopes of 3 and 3 to 1 was staked off. This levee extended from the main levee to the crib-work of the spur. The bank above and below it, where necessary, was graded to a reasonable slope, all holes and inequalities being filled up and leveled off. On the completion of the earthen levee it was covered with a layer of broken rock or brick 9 inches thick, and extending to form aprons 20 feet above and 50 feet below the spur levee. The project contemplated using gravel for this purpose, but the material mentioned was obtained at a reasonable cost and was equally as good. The broken rock or trash was the ballast of ships coming to the port, and the bricks were the refuse from brick-yards. On this layer of broken rock or brick was laid by hand a rough pavement of large rock, about 9 inches thick. Over this to fill in the voids was scattered broken rock, the whole forming a substantial covering 18 inches thick of material that will not wash away or decay.

The following is a consolidated statement of cost and material for all four spurs:

1,839.39 tons rock, at $1.50	$2,759.06
694.94 tons broken rock, at 75 cents	520.65
508.55 cubic yards of broken brick	174.17
1,832 cubic yards of earth	0.00
Pay-roll, services	2,772.08
Rations, approximate, 2,135, at 30 cents	640.50
Tug *Tilda* fifty days, at $20	1,000.00
Total	7,866.46
Contents of spur levees and aprons as computed, cubic yards	4,058
Cost per cubic yard, completed	1.93$\frac{85}{100}$

I fear that the figures which I have given in this report are somewhat misleading. To avoid this I would state that on all the work the cost given is the bald cost as computed and incurred under my immediate supervision in the field.

It does not include cost of large plant, such as barges, or care, preservation, and repair of same; nor of small plant, such as hawsers, lowering lines, tools, appliances, and the thousand and one small purchases incident to a work of this character. It does not include expenses in main office, such as traveling expenses, salaries, rent, stationery, etc., nor installation on work.

There are now twelve spur-dikes completed in the harbor. I do not know the total amount expended on this work to date, but if it were ascertained, the present value of the plant deducted, and the remainder divided by twelve, it would give the actual average cost of each spur. Fluctuating appropriations, unfortunate delays, etc., while they may explain will not alter the fact that the work is and is likely to continue to be very expensive through causes over which your executive force have no control.

As an offset to this, it may be stated that there is now every reason to believe that the work has been successful. The spurs are standing and accomplishing the results for which they were built.

Without elaborate drawings, photographs, etc., it would not be possible to give a proper idea of the methods employed or the details of spur-dike construction. Suffice it to say that nothing is done in a hap-hazard or careless way, but is the result of careful study improved by experience. From the time a mattress or crib is placed between the double line of lowering barges until it rests in its proper position on the bottom it is fully under control. No one unless those who have seen it can realize the accuracy with which the different structures are placed in water 100 feet deep and more. The profiles of the completed spurs are sufficient evidence. Improvements in details have been constant. Amongst the most important may be mentioned the use of a "mooring barge" from which all the mooring and toggle lines, are managed, the use of steel wire ropes instead of manilla hawsers for mooring lines, the substitution of the "built" for the "woven" mattress.

During the season's work no incident worthy of mention occurred. From date of commencement until work was suspended on account of high water, operations were carried on smoothly and successfully. The season throughout was the most favorable that I have ever known and a similar one is not likely to occur for some years.

The only disaster occurred since the plant has been laid up. On the night of May 8 the tug *Tilda*, which had rendered such excellent service in the harbor, was almost destroyed by fire. She had been absent on levee work at the Nita Crevasse and a few hours after her return was discovered to be in flames.

SUMMARY.

The working season of 1889–'90 commenced June 22, 1889, and all work in the Greenville Bend and third district front under the approved project was completed January 20, 1890, at which time the river had risen to a stage that prevented further work.

Total length of working season, days		213	Volume of cribs built and placed in spurs	cu. feet	974,287
Sundays	days	30	Quantity of brush used	cords	6,050
Holidays	do	3	Quantity of poles used	do	550
Bad weather	do	9	Quantity of lumber used, feet, B. M		201,300
Non-delivery of brush	do	5	Quantity of rock used	tons	6,956
Actual working time	do	166			
Area of mattresses built and placed in spurs	sq. feet	209,254			

At date of this report the river is generally out of its banks. The plant is in laying up quarters and, thanks to your wise policy, is generally in good condition, a large portion as good as new. Barge No. 3, now six years old, is being rebuilt. The *Tilda* has been docked in a coal-barge and the work of repairing the damage done by the fire is being pushed as rapidly as possible.

Mr. William Garvin has been a faithful and efficient overseer, and, together with Mr. Jos. Railey, time-keeper, has been of great assistance in accumulating the data given in this report.

In conclusion I would state that while every reasonable and proper economy has been exercised, such economy has never been at the expense of the character of the construction. It is, I believe, the best of its kind. I only hope that the third district work may not be taken as a criterion of cost. The results were obtained by an amount of hard work, persistent endeavor, experience, and watchfulness on the part of the principal employés which I would not be prepared to guaranty on all future work. The third district spurs were estimated in the consolidated project to cost $48,000. As computed in this report the cost was $33,574.48, a saving of $14,425.52.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

REPORT OF MR. W. G. PRICE, ASSISTANT ENGINEER.

SIMMESPORT, LA., *May* 31, 1890.

CAPTAIN: I have the honor to submit the following report of work done for the rectification of the Red and Atchafalaya rivers:

On the 31st of May, 1889, the condition of the work was as follows: Dam No. 1 in the Atchafalaya had been completed and work on Sill No. 3 had been suspended on account of high water. The fourth and last dump-scow and second large quarter-boat were in course of construction, and a rock-quarry was in operation at Harrisonburgh, La. The work at the quarry was suspended June 12, owing to low water, 1,675 tons having been delivered at Turnbull's Island. The fourth dump-scow, second quarter-boat, and two small barges for carrying coal and other supplies were completed in July. The three quarter-boats which had been borrowed from the work at Plum Point were repaired and returned to that work August 7. Ways were constructed on the bank of the river and five willow barges were hauled out and repaired at a total cost of $2,274. The sides and rakes were sheathed with 2-inch pine and the decks with 1½-inch pine. A covering of felt and pine tar was put on under the sheathing, but it was found necessary to calk the seams in the sides and rakes afterwards, so the felt was of little benefit except on the decks. This work was finished November 23.

OLD RIVER.

The dredge *Pah-Ute* (Menge patent) was moved to upper Old River June 15, and began dredging out shallow places and depositing material on one side of cut till August 7, when the water was too high. Four thousand three hundred and ninety-two cubic yards were dredged at a cost of 16.5 cents per cubic yard. On August 28 the dredge began work in lower Old River at Ash Cabin, but was soon moved to the bar at the mouth which was cut through September 11, and the work of cutting through second crossing to foot of Turnbull's Island was begun. On October 24 the dredge was returned to the mouth and again cut a channel through the bar assisted by the launch *Ruby* washing with her wheel. On October 31 the dredge was moved to Ash Cabin again and continued cutting out mud-lumps till November 22. From October 25 to November 8 only very small light-draught boats could pass through Old River, but on the latter date navigation was resumed, the mud-lumps in vicinity of Ash Cabin, which were the principal obstruction, having been removed by the dredge, and the steamers *John D. Scully* and *Dacotah* passed through. The gauge at Barbre's on that date read 2.6 feet, and at Red River Landing the gauge read 3.1 feet. Navigation was resumed at a much lower stage than for many years. There was some sloughing of the banks in vicinity of Ash Cabin, but not as much as last year. The banks are apparently becoming stronger, so the sloughing will eventually cease. The total amount of material dredged in lower Old River was 47,480 cubic yards, at a cost of 8.9 cents per yard, of which 1,761 cubic yards were removed in scows to Dam No. 3 in the Atchafalaya. The dredge was very imperfect at first and was continually breaking down, but the defects were remedied finally so that good work was done.

SILL AND DAM NO. 3 IN THE ATCHAFALAYA.

On June 5 a force began cutting willows in Old River, and on July 3 mat construction was begun. The Sill No. 3 was completed August 27, and Dam No. 3 was completed September 15. The method of construction was the same as for Sill and Dam No. 1. The dredge loaded 1,570 cubic yards of clay on scows at mouth of Bayou Des Glaise and 1,761 cubic yards in Old River, which was dumped in the successive layers of crib-mats in dam. All the mats were ballasted with rock. No gravel was used owing to the difficulty in obtaining it. At first there was too much water over the gravel-bars in the Mississippi, and afterwards the services of the dredge were required in Old River.

Material used.—Willows, 5,608 cords, at $1.59, delivered; rock, 3,635 tons, at $2.30, delivered; clay, 3,331 cubic yards.

There were constructed, ballasted, and sunk 975,990 cubic feet of crib mats at a cost of 3.4 cents per cubic foot. The cost of constructing mats including material was 1.6 cents per cubic foot, all expenses included except cost of plant and unexpended material.

In April, during the highest water, there was a perceptible fall over this dam and the velocity was very great. The strongest stern-wheel boats could not pass up except by going close to shore. At the discharge section, located 850 feet below the center of the dam, the area of the section below zero of Simsport gauge increased 31 per cent. from March 6 to May 14. I think this indicates that it will be necessary to put in more dams to distribute the fall over a longer reach.

DAM FOR DEFLECTION OF RED TO UPPER OLD RIVER.

Work was begun on the sill September 9 and it was completed November 15. That portion of the sill which is below 10 feet on the Barbre's gauge was constructed of crib mats 3 feet thick, same as used in Atchafalaya sills. The sill is 280 feet wide in the deep water and tapers out to 200 feet wide where the ends of the dam are to be. Twelve mats were constructed, containing 755,400 cubic feet, at a cost of 1.43 cents per cubic foot. The cost of mats ballasted and sunk was 2.65 cents per cubic foot, all expenses included except cost of plant and unexpendable material. All the mats were strongly wired together at their edges, one after another, as they were being sunk, and the whole was put down in one continuous piece from one side of the river to the other. The mats were ballasted with 23 pounds of rock to the square foot. The direction of the sinking was across the river, the rock being thrown on the mats from barges which were pushed over the mats as they went down. Owing to the slack current the work of sinking was extremely easy and cheap and the perfect covering of the bottom was a certainty. The sill over the bar and up the bank on each side is 200 feet wide, and was made by laying down two courses of willows, 3 to 4 inches thick, crossing each other, the direction of the willows in each course being diagonal to the sill. This was ballasted with rock piled in rows 12 feet apart and running across the river. Twenty-four pounds of rock to the square foot was used on the bar and right bank and 28 pounds per square foot on left bank. The area covered was 407,720 square feet, and cost 5.7 cents per square foot. A portable railroad with cars hauled by mules was used to distribute the rock over this portion of the work. The track led over a trestle to the rock barges in the river. The rock was obtained at Harrisonburg and Pineville, La., and had been stored in the vicinity during the preceding high water. The willows were obtained from the bars in the immediate vicinity. Grading was only required on the left bank, which was cut to a slope of four to one, using a water jet from pile-driver pump. The new quarter-boats enabled us to take much better care of the force employed and there was much less sickness.

Material used.—Five thousand seven hundred and fifty-seven cords of willows, at $1.31, delivered; 7,815 tons of rock, at $2.30, delivered; 113,392 feet of lumber, at $15 per M, delivered.

On November 16 the plant was moved to Plaquemine to be used in constructing submerged spurs.

REPAIRS TO PLANT.

On February 6 the plant arrived at Simmsport from Plaquemine. A dock was constructed out of an old coal-boat, in which the launches *Ruby* and *Alaska*, quarter-boats *Alpha* and *Beta*, and tug *Comstock* have been docked and had their hulls thoroughly repaired, calked, and painted. A new cabin is being built on the *Comstock* and improvements and repairs are being made to her machinery. All the barges in the plant have been put in good order except three old ones which are not worth repairing. Owing to the very high water most of the property had to be moved from the buildings on shore and stored on the barges and quarter-boats.

SURVEYS.

Sections in Atchafalaya from Barbre's to Simmsport were resounded in November. Sections in Morganza were resounded in October.

DISCHARGE OBSERVATIONS.

I began measuring discharge at Red River Landing February 20, and at Simmsport March 6, using current meter. Since March 20 Mr. G. Ed. Mott has been the observer. Twenty-one discharges have been taken at Red River Landing, fourteen at Simmsport, and two at Natchez. All have been computed.

PROTECTION OF LEVEES.

The launches *Alaska* and *Ruby* have been employed most of the time since March 19 in the work of protection of levees between Simmsport and Bayou Sara, Louisiana. A large amount of lumber and sacks was distributed by the *Ruby*. The *Alaska* was used in patrolling the levees, and being a very fast boat material was taken to threatened points very quickly. A pile-driver was also kept ready for work with a supply of tongued and grooved sheet-piling aboard. The piling was made of three planks, each 2 inches by 12 inches, bolted together. The center planks were all carefully dressed to the same thickness, and they projected 2½ inches beyond the edges of the other two to form the tongue and groove. The driver was used only once, where a bad hole through a large levee at Fisher's Landing was stopped by driving sheet-piling

on the river side. The levees nearly over the whole line had to be raised, and they were successfully held against the rising river till April 21 and 22, when a severe rain and wind storm caused many breaks. Soon after the Morganza Levee broke a mattress was constructed and sunk to hold the lower end of the levee, which was caving away at the rate of 100 feet per day, and it has successfully protected the end of the levee. It was constructed, in accordance with your direction, of willow fascines 50 feet long and 1 foot in diameter, bound with rope. Enough fascines were fastened together side by side to make a mat 50 feet by 125 feet. It was built from ways placed on the slope of the levee, and when finished was towed to position and sunk. Nothing but willow brush and rope was used in constructing it, and it was ballasted with rock in double sacks tied on to the ropes in mat. One end of the mat was supported by a small lowering barge, and the swift current running under the mat helped to support it while the rock was being tied on. The men began tying rock on the end nearest the crevasse, and moved along gradually as the mat sunk down so their trips were in water. When all the rock was in place the end of the mat at the barge was quickly lowered to the bottom. The fascines made the mat very stiff in one direction, and prevented its doubling up, and as they were fastened with rope the mat was very easy to bend in the other direction, and it wrapped around the end of the levee very nicely. When sunk the mat was 60 feet from end of levee, and the levee caved away till the mat wrapped around the end.

MISCELLANEOUS.

Cost of subsistence during the year.

Cost of raw ration, including ice	cents..	32.5
Cost of ration cooked and served, including ice	do...	43.7

Expense of steam-boats while in commission.

Tug *Comstock*	per day..	$17.55
Launch *Ruby*	do...	16.13
Launch *Alaska*	do...	9.97

Very respectfully, your obedient servant,

W. G. PRICE,
Assistant Engineer.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

REPORT OF MR. WILLIAM GARVIN.

NEW ORLEANS, *March* 24, 1890.

SIR: I have the honor to submit the following report of the observations taken at Harlem Crevasse:

The break measured 49 feet in length with 8 feet depth on up-stream and 7.5 feet on down-stream end. The greatest velocity of the current, taking a distance of 100 feet, 50 feet on river and 50 feet on land side of center line of levee, I found to be 600 feet per minute or 6.81 miles an hour.

The floats used were pieces of timber 3 by 6 by 10 inches; the distance was ascertained by mooring the skiff to a willow on river side of crevasse and running out lead line with buoy on lower end. The man in skiff would call time when starting float and another call time when the float passed the buoy. I also ran floats from 50 feet outside to center line of levee; the velocity there I found to be 750 feet per minute or 8.52 miles an hour, which, in my opinion, is the most correct, as a lot of heavy drift lodged 75 or 80 feet below crevasse, caused a great many whirlpools and breakers below or on land side of center line of levee. At times the floats would stand stationary for a second or two on the breakers and under the most favorable circumstances would require six seconds to run the lower 50 feet. This drift also made it very dangerous to attempt to sound the center of break.

The gentlemen who were in charge of the work closing the break thought it much deeper in the center, but from the appearance of the flow of water I could see no reason why it should be much, if any, deeper than I found it, 5 feet from each end.

Assuming the depth to be 8 feet and velocity of current 750 feet per minute, the break would have a capacity of 294,000 cubic feet a minute.

On my way down I passed the Jesuits Bend break; it being behind quite a large batture and heavy growth of willows, it could not be seen from the river. I returned to this break at 4 p. m., but owing to the location found it impossible to take any

accurate measurements; the willows at this point grow within 15 feet of the levee, which made it impossible to run floats through the break. There were no obstructions on the land side of this break, and I ran some floats from center line of levee, estimating the distance, and found that it required from seven to nine seconds for them to run 100 feet; the same results as at Harlem break on the river side. There was 4.5 feet of water on ends of break, but every appearance of a greater depth near center; I estimate the length at 90 feet.

It would have required five or six hours' time to take accurate measurements and soundings in the Jesuit Bend crevasse.

Should I be sent out on work of this kind again, I will have a better knowledge of what is required and be prepared for any emergency.

Very respectfully your obedient servant,

WILLIAM GARVIN.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

REPORTS OF MR. B. J. OLIVEIRA, OBSERVER.

NEW ORLEANS, *March* 24, 1890.

CAPTAIN: I have the honor to submit the following report of the observations taken at "Nita Crevasse," St. James Parish, La., about 63 miles above New Orleans, March 23, 1890:

The break measures 642.1 feet in width, and an average depth of 14 feet. The velocity of current through the break was ascertained by surface floats, and was found to be 12.44 feet per second. To ascertain the mean velocity, 20 per cent. reduction was taken from same, leaving 9.925 feet per second, thus making the actual discharge 89,462.5 cubic feet per second. The floats used were made with pieces of timber 4 by 6 by 12 inches, the distance being ascertained by measuring between the old and new levees, and was found to be 140 feet. A man was stationed at the end of the old levee, and the float was thrown, and when it passed in line he would call, and another man was stationed at the end of the new levee who would call time when the float passed in line with him. Ten floats were used. The time was accurately registered for each float. The greatest time for a float to pass said distance was thirteen seconds, and the shortest time was nine and one-half seconds. The Mississippi Valley Railroad Company have built about 80 feet of piling out from the north end of the crevasse, and soundings were taken from the piling with results varying from 13 to 15 feet in depth. Platforms were also rigged with an upright post in the center varying from 12 to 20 feet. The posts were worked on a pivot, and railroad iron lashed to the bottom of each post. One at a time was sent through the crevasse. Every time they would touch bottom the projection at the top would be pushed to an angle, and by experimenting in this way I ascertained the average depth of the break to be 14 feet.

Very respectfully,

B. J. OLIVEIRA,
Observer.

MARCH 25, 1890.

Since the date of my report, I have learned from the officials of the Mississippi Valley Railroad Company that a cave of 20 feet more has occurred at the south end of the crevasse.

B. J. OLIVIERA.

Capt. DAN. C. KINGMAN,
Corps of Engineers, U. S. A.

NEW ORLEANS, MAY 21, 1890.

SIR: I have the honor to submit the following report of discharge measurement taken at Nita Crevasse May 20, 1890:

The accompanying sketch [sketch omitted] will show the line followed to obtain observation, which I judged to be a section of the water passing through the break. The line starts at a point 3,500 feet back of the levee, at north end of break, and continues until within 450 feet of the south end, where the current was too strong to proceed further.

Twenty-two soundings were taken with a pole, the depths ranging from 5 to 12 feet, and the same number of meter readings, taken with a "Price" current meter No. 23, with results showing velocity of 4.25 to 8.437 feet per second, making the total discharge for actual line taken to be 301,985 cubic feet per second.

I think about 45,000 cubic feet should be added to the discharge as allowance for the 450 feet at south end of crevasse where the current is very strong, and about 10,000 cubic feet for water wasted at north end in space between the levee, and 3,500 feet where section begins, which would make total discharge of crevasse 356,985 cubic feet per second.

Very respectfully, your obedient servant,

B. J. OLIVEIRA.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

NEW ORLEANS, *March* 26, 1890.

CAPTAIN: I have the honor to submit the following report of the observations taken at "Live Oak Crevasse," Plaquemine Parish, La., about 26 miles below New Orleans, right bank.

The same method was used in obtaining the necessary information as for the "Nita Crevasse," with the following results:

The break measures 116.7 feet. Average depth, 6½ feet; average velocity, 7,754 feet per second. Discharge, 5,881.8 cubic feet per second. There is a heavy growth of willows in front of the break, which causes the small rate of velocity.

Very respectfully, your obedient servant,

B. J. OLIVEIRA,
Observer.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

REPORT OF MR. W. J. HARDEE, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *May* 9, 1890.

CAPTAIN: In accordance with your verbal instructions of the 6th of May, I inspected and measured the Myrtle Grove and Nita crevasses and have the honor to submit the following report of my observations:

Both crevasses were visited on the United States tug *Tilda*, the steamer assisting in the work incidental to my observations.

Myrtle Grove plantation is situated 35 miles below New Orleans on the west bank of the Mississippi River. About one-half mile north of the residence of Mr. Wilkinson, the owner, is where the crevasse occurred. Here I found two breaks. By conferring with Mr. Wilkinson the history of the crevasses was learned.

During the morning of the 21st day of April a fearful wind storm prevailed. The water was two-tenths higher than the grade of the levee and held by a line of sacking. The line of levee in which these breaks occurred is a most miserable apology for a levee, and it is marvelous how it ever held water at all. During the period of flood and prior to the maximum height the levee had been re-enforced with earth placed on the back slope, giving it slight additional strength. The lower break occurred first. A large leak showed itself about 15 feet in the rear of the levee, spouting water from a 2½-foot diameter hole to a height of 3 feet. Mr. Wilkinson was on the levee at the time with his plantation force engaged in general protection work. A double line of hand-piling was immediately driven about the hole, horseshoe shaped, and when this had been filled with sacks and earth to a height of 4 feet, the levee in front of the spout collapsed, creating the crevasse. This was at 11 a. m. of April 21, 1890.

At 1 o'clock of the same day the upper break, 260 feet above, occurred. The high wind prevailing at the time lashed the water into long running waves which swept over the levee with such force as to wash it badly. Here five small breaks occurred directly due to wave wash; the small breaks gradually merged into one large opening. The ends of both gave way rapidly for about four days when all enlargement practically ceased and the ends at present are not apparently washing at all. At the time of my observation the water was just 1.8 feet lower than when the crevasses occurred. The original levee is about 5.5 feet high. Measures to close the crevasse were contemplated, but no work done. Here are the measurements found on May 7, 1890. Break No. 1: Width, 295 feet; average velocity 5.04 feet per second; average depth 3.5 feet; making a discharge of 5,153 cubic feet per second. Break No. 2: Width 540 feet; average velocity 2.18 feet per second; average depth 5.5 feet; discharge 6,474 cubic feet per second.

The observations at Myrtle Grove completed, journey was continued to Nita Crevasse, about 65 miles above New Orleans in St. James Parish, and measurements made May 8, 1890.

The origin of this break together with its early history is so well known that it will not be repeated. No enlargement is taking place at the north end. The south end is enlarging about 5 feet per twenty-four hours I was told.

By triangulation from opposite bank the width of the break was determined to be 2,892 feet. The mean velocity deduced from eight measurements, taken at different points in the crevasse, was 9.28 feet per second. The depth was found to range from 13 feet to as much as 20 feet immediately in the throat of the crevasse. The mean depth is placed at 15 feet. These measurements show a discharge of 402,566 cubic feet per second.

The following will serve to show the method by which measurements were ascertained at the crevasses herein reported on. The widths were determined by triangulation or stadia reading as was most expedient. Surface velocity was measured with floats between range lines, about equi-distant from and on either side of the center line of levee. This surface velocity was reduced 20 per cent. to acquire mean velocity. The currents in the crevasses were too strong to permit the use of boat and lead-line; therefore the depths were measured with perpendicular pieces or poles placed on a pivot in a square frame made of wood so as to float. Above and projecting from the water about 4 feet of pole extended. The pole was weighted so that it could carry itself vertically when the float was launched and the pole met no obstacle. When the pole would come in contact with the bottom it would incline the upper extension. The angle was noted and the depth approximated. These lower poles were of different lengths and numerous floats were sent through the crevasses at different points until the depths were determined. Owing to the impossibility of securing an accurate profile or cross-section of the bottom, it must be remembered that the discharge furnished is only approximate. The measurements were taken in such manner, however, as to insure reasonably correct figures.

Very respectfully, your obedient servant,

W. J. HARDEE,
Assistant Engineer.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER.

NEW ORLEANS, *May* 19, 1890.

SIR: I have the honor to submit the following report, in compliance with your directions to give a history of the crevasses on Tensas Front, fourth district, with measurements of discharge, width and depth:

LAKE CONCORDIA.

I can not give any very reliable information as to the cause of the break, as my information is mostly hearsay.

Within 150 feet of the break I had had some work done at the junction of the run-a-round of the 1884 crevasse and the old levee. On April 18 I made a careful inspection of the levee in this vicinity, and walked over the particular place where the break occurred. No weakness was shown. If anything there was less seepage than elsewhere. An inspection of the map will show that in this locality there are a number of bayous large and small closed by the levee. The bayous are separated by high ridges.

On April 22, about 10 a. m., the levee gave way about 150 feet above the run-a-round of 1884 on a ridge where the levee was about 6 feet high. The water lacked about 1 foot of being to the top. Twenty minutes before the break occurred horsemen had ridden over the levee and detected no signs of weakness. As described to me, the water burst through the embankment about half-way between the crown and toe. The crown fell in and the Lake Concordia crevasse of 1890 was inaugurated. In a very short time it had enlarged to 50 feet, caving into one of the bayous. There never was the slightest hope of closing it, the bayou and the nature of the soil making such a task hopeless.

On the morning of the 23d I visited the crevasse and inspected the levee generally. The weather was perfectly horrible, and every available man was engaged in trying to prevent additional breaks, leaving the one that had occurred alone, which was very wise. The crevasse at this time was 200 feet wide, with a very swift current rushing through it and tearing its channel all to pieces. As the crevasse of 1884 cut a channel of 60 feet deep on the line of the levee I knew that this one would do about the same thing, and that there would be no hope of rebuilding the levee on the original line. The great danger was that the upper wing of the levee closing the crevasse of 1884 would be undermined from the rear. I directed that operations be confined

to preventing this instead of protecting the ends, as I was particularly anxious to have the lower end cave off, so that the direction of the current might be changed and deflected away from the rear of the wing previously mentioned. I gave directions to make small rough mattresses of willows fastened with rope and ballasted with sand-bags to prevent the wash at the base of the levee. I considered then, and have not changed my opinion, that protecting the ends was of minor importance, and that a certain amount of caving would be beneficial.

On April 27 I again visited the crevasse, and found that the gap had increased to about 450 feet and that the current had slackened. A pile-driver and crew had been brought down from Vicksburg and a tug and barges had been chartered. A pile-dike had been constructed at the north end of the break and was apparently of temporary benefit, although it appeared to me to be undercutting.

I next visited the crevasse on May 2. The pile-work at the north end still held and but little caving had taken place. The lower end had caved into the upper wing of the levee of 1884, and as I hoped and believed all caving on the rear had been almost checked. Another pile-dike had been built at the south end, but it was undercutting faster than the force engaged could pile in sacks and brush. My next visit to the crevasse was on May 4. I found that the pile-dike at the south end of the crevasse had been undermined and flanked. The distance from the big dike closing the deep channel of the crevasse of 1884 to the edge of the break was 350 feet, and the end was slowly crumbling away into the deep channel that had been cut in the rear of the levee. Nothing but a very strongly built mattress ballasted with rock would have been successful in holding the end. Owing to the peculiar shape of the crevasse and the local topography the cross-currents and eddies were as strong as I have ever seen. At the end of the levee the current was boring a hole very much as would have been done by a large auger.

In my judgment in the time that would necessarily be consumed in accumulating the plant and material and constructing the martress one of two things would happen: The river would fall and confine the crevasse water to the deep channel which it had cut, or the break would have extended into the crevasse of 1884, when further enlargement would not be likely to occur.

The following special features may be mentioned in connection with the Lake Concordia Levee and Crevasse:

The soil on which the levee rests and of which it is built is peculiar. During the high water it becomes a saturated mass, only held together by the sod. A pole can be pushed through it at almost any point. The land slope becomes too soft for a man to walk over, and the amount of seepage through the embankment is astonishing. The point at which the present crevasse occurred is within a short distance of the Bayou Concordia, into which the water flowed and was conducted into a low uninhabited swamp. Within five days after the crevasse took place the backwater generally, and, incredible as it may seem, immediately back of the break, commenced to decline. But one plantation, the one on which the crevasse occurred, was extensively overflowed, and within 1,500 feet on either side of the break the front lands were not injured. On plantations 5 miles above the break planting operations were scarcely interfered with. The river has not yet caved its way into Lake Concordia except at the lower end, which is choked with a growth of willows, accumulated drift, deposit, etc. The steam-boat route into the lake is through the old Waterloo Crevasse shown on the map of Natchez and Vidalia Harbors. The line of old public and recent private levees on the river front is nearly continuous to this channel. The result is that as the river falls the crevasse is transferred from the lake bank to the river front.

On May 10 I measured the crevasse, with the following results:

Width	feet	837.00
Maximum depth	do	20.00
Average depth	do	13.35
Maximum velocity in feet per second	do	5.00
Average velocity in feet per second	do	4.21

Discharge 47,042.33 cubic feet per second.

ARNAULDIA.

The location of this break is about 1 mile below the town of Vidalia. The original break occurred on April 23, in a levee about 2 feet high, on a high ridge in front of a plantation quarters. A short distance below this was a levée about 5 feet high, recently built of almost pure sand and not sodded. Under the combined effects of rain and wave-wash this levee melted away. It is quite possible that both of these breaks could have been prevented by a little activity and energy, and but I fear that this was lacking on the part of those immediately concerned. The Concordia Crevasse had occasioned something of a panic, and the people were engaged in getting their stock out of the country, anticipating a general overflow. The first break was of no import-

ance, as it did not interrupt traffic on the public road immediately behind it, and the falling river quickly shut off the supply of water. On May 11 its channel was dry.

On May 11 I measured the existing crevasse, with the following results:

Width	feet	455.00
Maximum depth	do	3.50
Average depth	do	2.42
Maximum velocity in feet per second	do	2.00
Average velocity in feet per second	do	1.70

Discharge, 1,871.87 cubic feet per second.

HENDERSON-ASHLEY.

The only weakness of the Henderson-Ashley Levee was lack of height. It has a crown width of from 12 to 20 feet, and is, I believe, generally used as the public road. The weakest portion was a run-around built to close a gap caused by the caving into the river of a salient angle of the original line, and it was in this run-around that the break occurred. The levee, for a distance of about 4 miles, was generally overtopped by the flood, but it had been temporarily raised with lumber and sacks backed up with earth, making a second levee on the crown of the original one.

During the severe and prolonged storm of April 21, 22, and 23 breaks in this little levee on top repeatedly occurred, but they were closed. On the 23d, owing to the panic occasioned by the Concordia Crevasse, the force was somewhat demoralized and discouraged, and they let one of these little breaks get too far ahead of them. At this time the difference between the water in the river and the backwater behind the levee was about 4 feet. The crown of the old levee was too hard and compact to be cut away at once, but the rear slope, already softened by the backwater, washed away rapidly, until by undercutting of the crown the crevasse was made. It enlarged very rapidly to a width of 400 feet. On May 3 it had attained a width of 700 feet. The location of the crevasse is at the lower end of the Ashley plantation.

On May 12 I measured this crevasse, with the following results:

Width	feet	873.00
Maximum depth	do	13.00
Average depth	do	7.77
Maximum velocity per second	do	5.55
Average velocity per second	do	5.00

Discharge, 33,916.05 cubic feet per second.

METHODS.

The width of the breaks was measured with stadia. Depths were obtained with an ordinary lead line, and the soundings were taken from a skiff which was rowed across the jaws of the crevasse. Sixty-four good soundings were obtained at Lake Concordia, forty-seven at Arnauldia, and fifty-four at Henderson-Ashley. The measurements of velocity were made with an apparatus based on the old-fashioned log-line. It consisted principally of a reel on which was wound a light line or cord, tagged every 25 feet. To this was attached by bridle lines, so as to hold it square with the current, a triangular-shaped piece of thin board measuring 9 inches on a side. This was carefully weighted until its buoyancy was just overcome. A small float was attached allowing the board to sink 5 feet below the surface. One of the bridle lines was so arranged as to pull out when the board was suddenly checked by the log-line, and it could then be easily hauled in.

In operation two or more stations were selected about 75 feet outside the jaws of the crevasse. In most cases standing trees were convenient. The skiff was rowed up to and fastened to the station. The triangular board and the float were dropped overboard and the former immediately sank 5 feet below the surface. The current striking against the flat surface of the board pulled the log-line off the reel, which was arranged to run very freely. The stern of the skiff was taken as the zero point, and the time of the passage of the first tag was noted. The tags were then counted as they passed off the reel and the time noted on the passage of the fourth tag, thus giving a run of 100 feet. The board was then hauled in, the line wound up on the reel, and the whole operation repeated as many times as was considered necessary to obtain average velocity. The skiff was then removed to the next station, where the same observations were taken.

At Arnauldia, the depth being slight, and it being possible to measure a base at right angles to the break, the ordinary method of surface floats between two ranged lines was followed.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Capt. DAN. C. KINGMAN,
Corps of Engineers, U. S. A.

REPORT OF MR. W. J. HARDEE, ASSISTANT ENGINEER.

NEW ORLEANS, *May* 27, 1890.

CAPTAIN: I have the honor to submit the following report on crevasse measurements in the parish of Pointe Coupée, and East and West Baton Rouge, executed in accordance with your verbal instructions of May 19, 1890:

Departed from New Orleans on the steamer *Jesse K. Bell* at 5 p. m., May 19, and reached Bayou Sara at 5 a. m., May 21. Then proceeded by steamer *Stella Wilds* to Red River Landing, reaching there at 12.30 p. m. of the same day; secured a skiff and made the passage to Simmsport, arriving at the United States fleet at 4.30 p. m. Found the steamer *Ruby* somewhat dismantled and about to be put in dock. Her boilers were washed, cylinders packed, the boat provisioned and fully equipped for the trip, and left exactly at 8 p. m. Red River Landing was reached at 10.15 p. m. and the boat laid up for the night. Got under way at daylight May 22. At Tunica met the steamer *Laura Lee*, and as our coal was light, and fearing we would not have a sufficient quantity to carry us to Bayou Sara, I borrowed twenty boxes from the captain of the *Laura Lee* with the understanding it is to be returned to his boat at New Orleans. Early during the morning the

RACCOURCI CREVASSE

was reached. This crevasse is situated in the line of levee that crosses Brunette Point. The line of levee extends from Raccourci Landing across the point to Raccourci Bend of Old River, thence on to Smithland where it resumes its position near the bank of the Mississippi River. It was where this line of levee crosses the plantation of Mr. Horace Le Doux that the break occurred. The levee is a very old one. When built in 1866 was very small, and has several times been enlarged. Mr. James Cotton, a planter living near by, who controlled a force of labor on the levee during the flood, reports that during the life of the levee while encountering high waters, bad leaks showed themselves. These leaks were worked on and the material so placed as to construct a camel hump both on the crown and side slopes. Many similar points at present exist. The last time the levee was raised, some four years ago, the contractor in putting the enlargement on the front side cut away some of the humps on the back slope. It was where there had been a hump and which had been cut away that the break occurred. There had been no unfavorable weakness indicated, and Mr. Cotton passed over the place only a half hour before.

At 9 p. m. of April 22 a spout of water as large as a flour barrel burst out of the ground just where the back slope of levee meets same. In less than ten minutes the crown of the levee collapsed, and for ten days afterwards the break rapidly increased until the present dimensions were reached, when all virtual enlargement ceased. Height of levee in which break occurred is 6 feet.

The water at its highest, and at the time of crevasse, was flush with the grade, and wave overflow detained by a line of planking. The present elevation of the water is 4.4 feet below the grade of levee. In the center of the crevasse a deep hole has scoured, measuring as much as 40 feet, and as no such body is passing through the break, the depths for discharge computations were taken on the batture in front, and the velocity of current measured at the same point.

Statement.

	Feet.
Average of eight velocity measurements, per second	4.32
Average depth of ten measurements	3.30
Width of break	380.00

Discharge, 5,417.28 cubic feet per second.

Journey was continued, and shortly the

UPPER MORGANZA CREVASSE

was arrived at. This break is situated nearly a quarter of a mile from the river bank, in a very dense growth of young cotton-wood trees. The levee appears to be a very stable piece of work, standing about 8 feet high and covered with a heavy growth of closely cropped Bermuda grass. As the flood increased this levee was seen to be too low, and was raised with sacks and earth until its elevation was increased 1.1 feet. About midnight of April 21 the crevasse occurred, and was brought about by the waves lashing over the levee, which already fully saturated and soft proved an easy victim, and an opening was soon washed. At that time the water was almost flush with the new grade. On May 22, the date of my observation, the water was just 7.7 feet below new grade. The crevasse waters were so turbulent as to render

passage through the crevasse extremely hazardous, except at one point, where a successful journey was made. From the appearance of the water I judge large holes have scoured where the base of the levee rested. The depths were taken on a parallel line to levee, about 125 feet to river side. Here passage was made, in the skiff, through the trees, and was not only very difficult but very dangerous. Only expert boatmanship by the four in the skiff prevented capsizing. The current was measured on the line of soundings. The width was determined by stadia reading. The south end of the break is just 300 feet north of the 0 station of the new Morganza Levee. From an old negro fisherman, who frequents the crevasse daily, it was learned that all appreciable enlargement ceased several weeks ago, and the ends are now holding.

Statement.

	Feet.
Average velocity of seven measurements, per second	5
Average depth of eleven measurements	8
Width of crevasse	790

Discharge, 31,600 cubic feet per second.

All measurements completed we returned to the *Ruby* and dropped down to New Morganza; went in and followed the extreme southern chute, and in a few moments drew up at the south end of

NEW MORGANZA CREVASSE.

This break occurred about midway the new levee constructed in 1886–'87 by the State and Government jointly, and practically in the bed of the old crevasse. The levee was to all appearances very stable, and could have well stood a height of water within a foot of its top. It was well grown over with Bermuda grass. Owing to the great height pursued by the flood, it like many others had to be raised. The height was increased just 1.4 feet with sacks filled with earth and protected against wave overflow by line of planking. The crevasse occurred during the night of April 22. Its direct cause is not known, as no one was present. The space in front of crevasse is open and the wind has free action on the water. It is presumed that the water, then nearly flush with the new grade, agitated into waves, washed over, and created the break. For a short distance from each end there is a good stiff current, but out in the middle the current is very flat. The trip was made across the crevasse in a skiff and fifty-four soundings taken. The greatest water found was 19 feet, the least 7½ feet. By reference to the profile I find that the height of levee at north end of break was 13.2 feet. The water-surface at date of measurement, 5.7 feet below grade. This, then, if only the levee had washed away, should show a depth of 7.5 feet of water, but instead there were 13 feet showing a wash of 5.5 feet. At the south end, levee 9.5 feet high less 5.7 feet, should be 3.8 feet, but there were found 16 and 18 feet, showing a scouring of from 12 to 14 feet. Through the center of crevasse, where the ground was lowest, there was least wash, and where highest the most wash. The amount of wash or change of elevation ranges from 2 to 10 feet. As nearly as can be judged, the present profile would, in contour, closely compare with the original, but with a rather uniform difference in elevation.

The levee between the limits of break when constructed ranged from 5 to 24 feet in height. Owing to the difference in depth and velocities the discharge was calculated in divisions. On the 1st day of May Mr. Price, under your directions, successfully launched a large willow mat 50 by 125 feet, one end of which was connected with the south end of levee, the other allowed its freedom in the water, swung round, and now stands away from center line of levee at an angle of about 60 degrees. The end of mat is perfectly secure, and no enlargement has taken place since the mattress began serving its purpose of diverting the current from the end of levee. All enlargement at upper end stopped several weeks ago.

Statement.

	Feet.
Mean depth of fifty-six measurements	13.117
Mean velocity of fourteen measurements, per second	4.378
Width	2,543

Discharge, 146,034.88 cubic feet per second.

Measurements concluded, the return journey was through the same chute. The Mississippi River reached, the boat was headed down-stream, and after a short run the

SNEAD BREAK

was reached. Here the levee is of most inferior proportions. While well sodded, its crown is very small and the slopes insufficient. The levee stands 6 feet high. It

was originally much smaller, and increased to that height under a State contract about eighteen months ago. Mr. Snead reports that during the night of April 21 a very heavy wind and rain storm prevailed. The water in the river was just about flush with the top of the levee. At this point no sacking had been placed on the levee to raise it. A line of planking laid along the front edge of crown detained wave overflow. Immediately after the break, which occurred at 9 p. m., April 21, five large logs were found close by in the rear of the crevasse. No one having seen the crevasse occur, and not knowing its direct origin, it is thought by the residents that these immense logs were precipitated against the frail dike with such violence by the wind and waves as to burst through it. In this crevasse from the center line of levee towards the rear a large scour is indicated on the water-surface. Owing to the turbulence of the discharging waters no soundings could be secured in the surmised hole. The depths registered were taken on a parallel line just in front of the river-side slope, and as current measurements were taken over same course a correct discharge was ascertained. All enlargement of break stopped within ten days after date of break. River now 5 feet below top of levee.

Statement.

	Feet.
Average depth of seven measurements	3.56
Average velocity of three measurements, per second	6.00
Width of break	147.00

Discharge, 3,139.92 cubic feet per second.

In the same line of levee and about 500 feet south of the Snead Break is the

STONEWALL OR LANAUX CREVASSE.

This break occurred about 9 p. m. of April 21. The water was flush with the top of the levee. To provide against wave-wash a line of planking was placed along the river edge of crown. During the day of April 21 a most severe wind and rain storm prevailed, extending into the night. The waves lashed by the wind ran very high, and the planking proved inadequate to entirely oppose so severe a strain and the continued washing over of the waves tore an opening in the levee. This levee is 6.3 feet high. Its height was not increased during the flood. The piece where break occurred had been thrown out and a run-a-round built in the rear of it. The run-a-round, however, was never used, as the levee thrown out was shortly afterwards enlarged and made a part of the system. To drain that little territory encompassed by the levees, about one-fourth of an acre, the new levee was cut. When break occurred in front line the discharging waters continued on through the opening in new levee, and by their force enlarged the ends of both openings. All enlargement took place during first ten days succeeding date of crevasse. Water in river 5.05 feet below grade in levee.

Statement.

	Feet.
Average depth of seven measurements	3.36
Average velocity of three measurements, per second	6.00
Width	151.00

Discharge, 3,044.16 cubic feet per second.

Journey was continued, and a short run brought the boat to the

FANNY RICHE CREVASSE.

Here I found Mr. J. H. Stonaker, who informed me that this break occurred at 9.30 a. m., of April 21. Shortly before that hour the tow-boat *W. W. O'Neill* passed up in mid-stream. The waves created by her wheel broke away a large amount of the planking along this front. The planking gone, the swell occasioned a slight wave overflow at several points. At one of these points the crevasse occurred. Mr. Stonaker passed by the place not longer than twenty minutes before. While returning, and on reaching the spot referred to, he observed a large crack in the rear slope of the levee. This crack rapidly enlarged. A messenger was dispatched for a levee force engaged about a half a mile above. In less than ten minutes, and before the force could arrive, the broken piece slid out, the crown collapsed, and the water burst through. The break occurred within 150 feet of the present north end of crevasse. Enlargement was rapid for first ten days, extending almost altogether downstream. For past ten days no practical enlargement. This is a 6-foot levee. During the period of the flood, for lack of height, this levee was raised 1.6 feet with dirt and sacks, and the water stood about flush with the new top. On day of measurements river water 4.7 feet below new grade. Owing to great change of depth and velocity at different points in the crevasse, the discharge is computed in divisions.

Statement.

	Feet.
Average depth of seventeen measurements	7.371
Average velocity of eight measurements, per second	4.354
Width	845

Discharge, 27,118.84 cubic feet per second.

It was now nearly sunset, and as Bayou Sara was reached night was fast approaching. A mooring was secured, and at daylight the following morning, May 23, we steamed away and headed for the point just below and on opposite bank, where is situated the

PRESTON CREVASSE.

Here I found Mr. W. H. Lewis, the manager of the Preston plantation, who kindly furnished me with the following history of the break and its closure. The crevasse occurred at midnight, April 21. During the flood the levee was seen to be too low to oppose the increasing water elevation, and was raised with sacks and dirt a total of 0.9 foot. To provide against wave-wash a line of planking was positioned at river edge of crown. No particular weakness was known at the point where crevasse occurred. No one was on the spot at the time. The general impression and conclusion is that the waves, then running very high from the storm winds, washed over, and so continued until the levee succumbed to the destroying agency. At time of break water was about flush with the increased grade. This crevasse was closed May 17 with a line of 4 by 4 foot piling driven perpendicularly about 4 inches apart and sufficiently braced with other small piling, connected by lateral bracing, to retain structure in its position. Sacks filled with earth were then deposited on the river side of the line of piling until an elevation above the water was reached and the body compact enough to check all free percolation. All material used was furnished by the United States Government. Work was commenced on May 12 under the general superintendency of Mr. Bennett Barrow, and, as stated, concluded May 17.

A large and deep hole has scoured in the body of the crevasse, measuring as much as 45 feet in places. Soundings were also made about half-way between center line of levee and crib work. As water receded in rear with closure of crevasse the material in levee between the ends of crib and ends of break were borrowed to fill sacks. The linear distance of levee cut away for such purposes amounts to 230 feet. On the north end the cribbing was started 132 feet from end of break. The greatest distance between cribbing and center levee line is at a point about one-sixth its distance from south end, where it measures 100 feet. Soundings were taken along the crib-work on the inside.

Statement.

	Feet.
Original height of levee	3.6
Raised height of levee	0.9
Width of break	213

Present river water, 3.5 feet below new grade. Water in break, 2.6 feet below river water.

About 3,000 feet below are two small breaks known as the

TAYLOR BREAKS.

Break No. 1 is the lower. This levee had been raised prior to the crevasse and protected from wave-wash by line of planking. About 9.30 a. m., April 20, the waves ran over the top of the levee creating the break. No scouring took place, and on May 11, this break was closed by a line of inch boards driven in the ground as piling, and re-enforced with sacks filled with earth deposited on the front side. This structure was placed immediately at foot of river-side slope. At the time of break water was just flush with new grade.

Statement.

	Feet.
Original height of levee	3.7
Raised height of levee	1.4
Present water under new grade	3.6
Average depth of break below new grade	3.4
Width of break	203

No. 2, or upper, situated about 600 feet north of No. 1, and is in the same line of levee. It was closed as No. 1, and on the same day, May 11.

Statement.

	Feet.
Original height of levee	4.0
Raised height of levee	1.4
Present water below new grade	3.9
Average depth from new grade	3.7
Width	51.0

All of the foregoing crevasses are located in Pointe Coupee Parish, La., on the west bank of the Mississippi River, the succeeding two in West Baton Rouge Parish, on the west bank of the Mississippi River.

Measurements concluded at Taylor Breaks, the boat was headed for

POINT MANOIR,

where the conditions were peculiar. In the year 1886–'87 the State built what is known as the Point Manoir Levee, extending from Hermitage Landing down-stream a little more than a mile. This levee was to succeed a then existing levee very close to the bank of the river—a levee expected to cave in at any time. The levee, however, stood until recently. When the flood of this year came the residents' line of action was on the front or old levee. The basin between the old and new levee measured a little more than a mile long and in the center was about 2,000 feet wide, the ends inclining towards the river to almost a point. This basin had been partially filled with water by means of siphon. Great care is usually expended in such instances to make an opening in an old levee on the completion of a new or back line, that the new work may feel the effects of the water slowly and not be exposed to any sudden strain. Here then was a new line of levee but three and a half years old, without having been thoroughly moistened, lying exposed and subject to the great expansion of heat, causing large cracks and otherwise promoting instability. As was long expected, yet during the flood feared, a large cave occurred in the river bank at Hermitage Landing, carrying in with it a large piece of the old levee. This caved about midnight April 30. The sudden rush of waters caused the opening to enlarge, and it is now about 600 feet wide. So large a volume of water suddenly precipitated into the limited basin filled it rapidly, and within one hour after the cave the water in basin and river were of equal height, in places water standing flush with the top of the new levee. To all appearances the levee is a stable embankment. It has a good full crown with regular and well filled slopes, all of which are closely covered with a heavy mantle of Bermuda grass.

The strain so suddenly given this levee could scarcely be expected to create less damage than was effected. From Mr. A. Le Jeune, who controlled a patrol force on the Point Manoir front, I learned that he passed over where the break occurred only a few minutes before same took place on a tour of inspection. As he returned he observed a large stream of water issuing from the rear slope about half-way up. He dispatched his companion for a force of men, but only a few minutes elapsed before the crown of the levee fell in, and the material of sand and light loam washed rapidly and within the half-hour a large and angry break was operating. This break is located at the lower end of the levee and is in the main curtain, the south end resting at the angle where wing turns to meet old levee on front. The break occurred very near the present north end and extended rapidly down-stream. At present, since the closure at Hermitage referred to below, the break is entirely dry. Virtually no scouring took place. The surface of virgin soil is barely more than broken in places, in others undisturbed. The work was so clean yet indestructive as to clear the muck ditch of material placed in it, giving it the appearance of just having been cut.

Statement.

	Feet.
Height of levee	10.60
Water below grade at time of break	2.00
Width of break	571.00

At Hermitage Landing the Point Manoir Crevasse was closed. Operations were directed by Mr. Martin Glynn, assisted by the Sewall Brothers, with their patent piling. Work was commenced on the 9th of May and concluded May 17. Work was commenced on north end. When about midway across the draught became so great that the Sewall piling could not be driven securely, and after two unsuccessful attempts a line of cribbing and sacks similar to that used at Preston was established, circular in shape on the front side. The current checked, the Sewall piling was continued, but from that point to southern juncture with levee a strong re-enforcement of sacks was placed as high as present water-line in front of this Sewall piling.

Soundings were taken at each 100 feet along the crib-work. At highest stage water was just above grade of old levees and held by a line of planking and sacks.

Statement.

Water when break occurred, below highest water	feet..	2.30
Present water, below highest water	do...	4.20
Length of piling	do...	980.00
Average depth of water	do...	2.82
Area of discharge	sq. feet..	2,763.60

After a short run the

LOBDELL CREVASSE

was arrived at. Mr. A. A. Alford, the manager of the Lobdell Plantation, was seen, and says that the break occurred at 4.30 p. m., April 22. The levee is a large and high one, standing 1.7 feet above the highest water of this season. It has a wide crown and good full slopes, and the entire levee is well sodded with closely cropped Bermuda grass. I was told the only weakness noticeable during the flood was a free seepage of water through the extreme base of levee, and also through the ground on which it rested. Just behind the levee and very near where the breach was made, there lived an old negro who says that suddenly there burst out of the ground immediately at the foot of the rear slope of the levee a large spout of water as large as a flour-barrel. In a very few seconds the top of the levee collapsed. The crevasse enlarged rapidly for ten days. The enlargement traveled up-stream mainly, the break having taken place near the present south end. No change in past two weeks at south end; less than 50 feet have broken off of the north end. Immediately in front of the levee is a high batture, thickly grown with timber, over which flows not more than 1 foot of water. The deepest water and greatest discharge is near each end, particularly the north end, where there is an open and deep channel.

Statement.

	Feet.
Height of levee	10.000
Water below levee when break occurred	1.700
Water below levee at present	7.500
Average velocity of nine measurements per second	4.117
Average depth of twenty-seven measurements	7.221
Width	1,981.000

Discharge 58,892.81 cubic feet per second.

On the morning of May 23, the date of foregoing measurements, the steamer *Dacotah* arrived with men and material in charge of the Sewall Brothers, and commenced a line of cribbing. No assistance is being lent in this work by the United States Government. The Sewalls do not intend under the present plan to continue their crib-work all the way around, and fully stop the crevasse. They propose to cut off the supply and decrease the discharge so that the then small amount of water escaping will cause no inconvenience to the planting interest. Their plan will be a failure. As soon as the current in the chute they are trying to dam is thrown against the sand lump they intend joining, it is almost a positive fact that it will destroy it and leave no terminus for the piling other than the almost perpendicular bank of the river. Admitting that their prospective terminus will hold, it is reasonable to suppose that the batture immediately in front of the crevasse, being of sand, will rapidly give way and assume a capacity equal to that now furnishing the crevasse.

Leaving Lobdell, a run of about 30 miles brought us to

MARTINEZ BREAK,

situated about 12 miles below Baton Rouge, in East Baton Rouge Parish, and on the east bank of the Mississippi River.

Dr. John T. Jones was seen and furnished information concerning the break, which he says was occasioned by the washing out of a rice flume, and occurred in the night of April 22, during a heavy wind and rain storm. The water was just .3 foot under the grade of the levee, and now and then the waves, dashing with great violence against the line of planking that had been put down at the low places in the levee, would run over. This break enlarged to its present width within twenty-four hours, when the ends were secured. Work of closing was inaugurated April 24 and completed on April 28.

Statement.

Height of levee	feet..	5.00
River below grade at time of break	do...	.30
River below grade at date of measurement	do...	4.70
Water inside of break at date of measurement	do...	6.80
Average depth of seven measurements at crib	do...	19.70
Width	do...	124.00
Area of discharge	square feet..	2,440.80

Between the ends of cribbing and ends of break there were 234 feet of levee borrowed and filled in sacks to put in break.

The *Ruby* was now headed for Baton Rouge, which place was reached about 7 p. m. of May 23. The entire measurement of the foregoing crevasses consumed exactly two days' work. My movements were much expedited by meeting at each crevasse some one from whom an authentic history of the break with dates, etc., was obtained.

The *Ruby* was ordered back to Simmesport, and departed from Baton Rouge at 6.30 a. m., May 24. I left a few moments later by train for New Orleans, reaching here at noon.

Very respectfully, your obedient servant,

W. J. HARDEE,
Assistant Engineer.

Capt. DAN. C. KINGMAN,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

CUSTOM-HOUSE, NEW ORLEANS, LA.,
Collector's Office, June 9, 1890.

SIR: Inclosed please find reports from the deputy collector and auditor covering the statistical information asked for in your letter of the 19th ultimo.

Respectfully yours,

W. L. MCMILLEN,
Special Deputy Collector.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

	Entrances.		Clearances.	
	Number.	*Tons.*	*Number.*	*Tons.*
Steam	984	1,261,908	980	1,262,706
Sail	160	79,904	144	65,757
Estimate for June:				
Steam	64	78,000	64	78,000
Sail	15	8,000	15	8,000
Total	1,223	1,427,812	1,203	1,414,463

Total value of exports, foreign merchandise, to foreign countries.

From July 1, 1889, to June 1, 1890	$759,569.00
Estimate for June, 1890	85,195.00
Total	844,764.00
Total value of foreign specie exported	28,680.00
Total value of domestic exports July 1, 1889, to May 30, 1890, inclusive	105,263,013.00
Estimated value for June, 1890	1,741,754.00
Total domestic exports for year ending June 30, 1890	107,004,767.00
Total foreign exports for year ending June 30, 1890	844,764.00
Total all exports for year ending June 30, 1890	107,849,531.00

Imports of specie and merchandise, free and dutiable.

Gold bullion	$17,726.00
Silver bullion	4,491.00
American gold coin	657.00
American silver dollars	1,476.00
Foreign silver dollars	420,866.00
Total for eleven months	445,216.00
Estimated for June, 1890	25,000.00
Total for twelve months	470,216.00
Also United States currency	32,320.00

Merchandise, free and dutiable.

Imports for eleven months:	
Free	$7,138,270.00
Dutiable	6,323,207.00
Total for eleven months	13,461,477.00
Estimated for June, 1890:	
Free	718,900.00
Dutiable	702,100.00
Total for month of June, 1890	1,421,000.00
Total for year ending June 30, 1890:	
Free	7,857,170.00
Dutiable	7,025,307.00
Total for year ending June 30, 1890	14,882,477.00
Collections for account of "Duties on Imports" for eleven months ending May 31, 1890	2,478,062.33
Estimate for June, 1890	175,000.00
Total for year ending June 30, 1890	2,653,062.33

Statement showing the amount and value of commerce passing out of Red River and its tributaries through Old River into the Mississippi River, compiled by Mr. W. J. Hardee, assistant engineer, from the river column of the New Orleans Daily States, and from assistance furnished by the commercial exchanges of New Orleans, Louisiana.

[The period embraced by this report extends from June 1, 1889, to June 1, 1890.]

STATEMENT.

Number of steam-boats	20
Trips made by them	318
Net tonnage of same	108,130
Number of barges	16
Net tonnage of barges	9,600
Total tonnage of steam-boats and barges	117,730
Total cargo brought (tons)	106,416
Value of same	$10,022,798

ARTICLES OF CARGO.

Apples	barrels	18	Eggs	packages	3,130
Apples, dried	do	6	Excelsior	bales	201
Bones	sacks	441	Flour	barrels	52
Bottles (empty)	barrels	612	Furniture	packages	132
Cattle	head	138	Grits	barrels	131
Cabbage	crates	6	Hides	loose	418
Corn	sacks	80	Hides	packages	1,195
Cotton	bales	170,912	Hogs	number	754
Cotton seed	sacks	595,189	Honey	barrels	79
Cotton-seed meal	sacks	21,646	Horses and mules	head	20
Cotton-seed oil	barrels	3,101	Kegs (empty)	number	158

ARTICLES OF CARGO—continued.

Lumber	feet B. M.	508,799	Sheep	head	121
Moat	bales	30	Skins	packages	14
Moss	do	1,313	Sugar	hogsheads	3,857
Molasses	barrels	13,062	Sugar	barrels	24,217
Miscellaneous	packages	250	Screenings	sacks	59
Pecans	barrels	61	Seed-cotton	do	59
Potatoes	do	170	Staves (oak)	number	701,455
Potatoes	sacks	301	Saw-logs, 10-foot lengths (no count made of tonnage)		30,800
Poultry	coops	83	Tallow	barrels	55
Pork	barrels	56	Wheels	bundles	196
Peas	do	41	Wool	bags	273
Peas	sacks	44	Wood	cords	3,679
Rice	barrels	10			
Rice	sacks	10,258			

This does not include the up-stream freights which must be nearly equal to the down-stream ones.

Statement showing the river arrivals at New Orleans, Louisiana, from June 1, 1889, to June 1, 1890, compiled by Mr. W. J. Hardee, assistant engineer, from the river column of the New Orleans Daily States, and from assistance furnished by the commercial exchanges of New Orleans, Louisiana.

ABOVE THE CITY.

Steam-boats (number)	58
Trips made by them	1,390
Net tonnage of same	547,000
Tow-boats (number)	36
Trips made by them	157
Net tonnage of same	70,490
Barges (number)	1,066
Net tonnage of same	478,906
Number of luggers (sailing)	4
Trips made by them	37
Net tonnage of same	1,110
Total tonnage (steam-boats, tow-boats, barges, and luggers)	1,097,506
Total cargo brought (tons)	1,716,405
Value of same	$64,619,122

BELOW THE CITY.

Steam-boats in local trade	4
Trips made by them	165
Net tonnage of same	18,674
Luggers (sailing) in local trade	205
Trips made by them	4,100
Net tonnage of same	123,000
Total tonnage (steam-boats and luggers)	141,674
Total cargo brought (tons)	19,986
Value of same	$1,612,847

RECAPITULATION.

Total arrivals, above (steam-boats, tow-boats, barges, and luggers)	2,640
Total net tonnage	1,097,506
Total arrivals from below	4,265
Total net tonnage	141,674

ARTICLES OF CARGO.

Acids	carboys	1,570	Barrel linings	bundles	2,000
Alcohol	barrels	22	Barley	sacks	139
Ammonia	drums	100	Beans	barrels and sacks	1,112
Apples	barrels	1,222	Buggies	number	11
Apples, dried	do	1,078	Bungs	barrels	177
Buckets	dozen	3,085	Beef	do	91
Bagging	rolls	26,273	Bacon	do	512
Baking-powder	boxes	118	Beer	packages	3,065
Barrels (empty)	number	2,065	Bitters	boxes	5,825

ARTICLES OF CARGO—continued.

Bones	sacks	697
Bran	do	99,122
Brushes	boxes	43
Bolts and nuts	kegs	520
Broom-corn	bales	2,198
Bellows	number	21
Blueing	cases	3
Bricks, fire	number	1,165
Butter	packages	270
Bottles (empty)	barrels	2,091
Brandy	do	1
Baskets	bundles	544
Candles	boxes	2,111
Cordials	do	1
Cattle	head	298
Crackers	boxes	51
Cabbage	crates	1,275
Cheese	cases	11
Canned goods	boxes	135
Cork	bags	1
Carts	number	47
Cement	barrels	1,550
Candy	packages	699
Cartridges	cases	12
Carriages	number	3
Cider	packages	275
Coal	bushels	10,580,000
Coke	do	133,000
Corn	do	14,107,385
Corn	sacks	323,679
Cross-ties	number	12,000
Cotton	bales	467,716
Cotton-seed	sacks	1,920,959
Cotton-seed meal	do	72,682
Cotton-seed ashes	do	702
Carbons	boxes	2,828
Cotton-seed oil	barrels	6,014
Corn-meal	do	99,328
Corn-meal	sacks	3,719
Chains	casks	845
Cigars	cases	1
Crockery	packages	5,681
Castings	do	1,666
Drugs	do	4,122
Dry goods	do	4,394
Eggs	do	7,368
Excelsior	bales	1,555
Felloes	bundles	6,566
Feed meal	sacks	9,177
Fire-clay	barrels	505
Flour	do	329,128
Flour	half-barrels	53,377
Flour	sacks	6,204
Fruits, dried	packages	30
Furniture	do	20,598
Furnaces	number	40
Flax-seed	sacks	25
Grindstones	number	4,080
Gin	barrels	12
Garlic	strings	1,208
Glass	packages	7,000
Glassware	do	8,051
Guano	sacks	170
Glucose	barrels	1,202
Groceries	packages	11,119
Glue	barrels	11
Grits	do	58,058
Hubs	bundles	699
Hops	bales	2
Hams	cases	787
Hair	bales	2,450
Hay	do	8,232
Hay	half bales	12,452
Hay	quarter bales	9,664
Hides, loose		747
Hides	packages	2,336
Hogs	head	946
Honey	barrels	326
Hoop-poles	number	371,613
Horses and mules	head	353
Hominy	barrels	297
Hose	package	1
Handles	bundles	4,553
Hinges	barrels	277
Horns	sacks	6
Hardware	packages	11,002
Iron	do	23,046
Ink	boxes	209
Irons, heating	do	308
Kraut	barrels	241
Kegs (empty)	number	1,872
Lard	packages	37,630
Lead, pigs	number	1,611
Lead, sheet	boxes	505
Lye	cases	55
Linseed-meal	sacks	5
Lime	barrels	3,887
Lumber	feet B. M	1,342,633
Mops	dozen	233
Mattresses	number	245
Mattresses, wire	do	439
Mucilage	boxes	219
Moat	bales	383
Mats	dozen	88
Molding	bundles	12
Moss	bales	7,586
Malt	sacks	17,681
Molasses	barrels	169,758
Milk	cases	1
Mirrors	boxes	2,250
Meat	cases	124
Miscellaneous	packages	32,042
Nails	kegs	53,800
Oysters (shell)	barrels	2,070,000
Oats (bulk)	bushels	49,707
Oats	sacks	434,091
Oatmeal	barrels	78
Oil	do	3,780
Oil-cake	sacks	73,035
Onions	barrels	3,131
Onions	sacks	34,182
Oranges	barrels	27,591
Oranges	boxes	58
Pots	number	1,524
Pipe	packages	2,601
Plows	number	4,605
Pecans	barrels	131
Pickles	do	99
Pickles	cases	8,589
Potatoes	barrels	94,717
Potatoes	sacks	69,769
Poultry	coops	412
Preserves	cases	273
Pork	barrels	339
Putty	do	51
Pitch	do	47

ARTICLES OF CARGO—continued.

Paint	packages	282	Saddlery	packages	621
Peanuts	bags	2,279	Spikes	kegs	1,199
Peas	barrels	339	Sirup	barrels	1,180
Peas	sacks	733	Steel-wire	packages	528
Pumps	number	59	Shrimp	boxes	14
Paper	bundles	419	Show-cases	number	321
Rope	bales	7,042	Saw-logs, 10-foot lengths (no count made of tonnage)		58,800
Rye	bushels	175,000	Twine	bundles	23
Rags	bales	113	Tallow	barrels	160
Rice	barrels	2,153	Tiles	pieces	1,950
Rice	sacks	433,036	Tobacco	hogheads	420
Rings	bundles	5	Tobacco	cases	1,738
Sheep	number	397	Toys	packages	148
Shot	pockets	4,084	Tubs	packages	25
Sirup of figs	boxes	750	Tin-ware	packages	796
Skins	packages	43	Trunks	number	1,693
Soap	boxes	6,066	Varnish	barrels	25
Soap-stock	barrels	306	Vegetables	packages	203
Single-trees	bundles	1,512	Vinegar	barrels	1,757
Starch	barrels	687	Wooden ware	packages	9,076
Starch	boxes	45,296	Wool	bags	396
Sacks	bales	66	Wax	barrels	5
Stone	pieces	19	Washboards	number	1,040
Shoes	cases	174	Wagons	do	6
Spades and shovels	bundles	262	Wheat (bulk)	bushels	2,200,208
Seed (garden)	packages	219	Wheat	sacks	2,260
Sash-weights	number	12,973	Wrappers	bundles	3,701
Staples	kegs	978	Whisky	barrels	78
Sugar	hogsheads	55,169	Whisky and wines	cases	58
Sugar	barrels	237,054	White lead	kegs	10,021
Straw	bales	3,684	White lead	cases	10,770
Screenings	sacks	1,394	Wine	barrels	190
Seed-cotton	do	783	Wood	cords	3,801
Staves (oak)	number	1,716,311	Wire	reels	28,555
Stoves	do	4,066	Wheels	bundles	239
Safes, iron	do	1	Washers	bundles	31
Spokes	bundles	3,079			

This list includes simply the freights brought to New Orleans by steam-boats and barges on the Mississippi River, and does not include the large and valuable freights that they take away. No record is kept of this, and it is impossible to furnish even a reasonably accurate estimate of its value. It would amount to a very large sum in the aggregate, probably more than fifty per cent. of the value of freights received at New Orleans.

Statement showing the approximate receipts and shipments of freight by river from June 1, 1889, to June 1, 1880, at Natchez and Vidalia, Bayou Sara, Baton Rouge, Plaquemine, and Donaldsonville, compiled by W. J. Hardee, assistant engineer, from information derived from the commercial exchanges of the respective towns and the several business houses and landings where the steam-boats receive and discharge cargoes.

It must be known that the above towns are, strictly speaking, "way points," and not termini; by virtue of that fact the net tonnage or carrying capacity of the steam-boats that do business at those places is not given, as it would not show the proper relation between what would then be made the possible tonnage and the actual tonnage hauled. All New Orleans steam-boats are counted "arrived" when they stop on their way up the river, and "departed" when they stop on their way down to New Orleans. St. Louis and Ohio River steam-boats are counted "arrived" when they stop on their way down the river, and "departed" when they stop on their way upstream.

Owing to the obscure records obtainable many articles of a like character are styled under one head.

NATCHEZ, MISSISSIPPI.

Receipts.

Number of steam-boats in trade	34
Number of times arrived	632
Number of barges	51
Total cargo arrived (tons)	82,084
Value of same	$1,581,823

ARTICLES OF CARGO.

Cotton	bales	13,468	Wet barrels	number	1,359
Cotton-seed	sacks	128,000	Wrapping-paper	packages	672
Lumber	feet B. M.	4,450,000	Sash, doors, and blinds	do	850
Coal	bushels	1,077,989	Hardware	do	11,899
Wood	cords	800	Groceries	do	20,398
Sacks	empty	1,200	Wooden ware	do	8,499
Corn-meal	barrels	42,496	Miscellaneous		1,359
Bran	sacks	8,499			

Shipments.

Number of steam-boats in trade	28
Number of times "departed"	626
Total cargo shipped (tons)	22,340
Value of same	$1,369,539.00

ARTICLES OF CARGO.

Cotton	bales	12,214	Oats	sacks	67,994
Cotton cloth	yards	2,750,000	Corn	do	34,020
Cotton-seed oil	gallons	45,300	Bran	do	6,800
Cotton-seed meal	sacks	11,320	Wet barrels	number	1,088
Cotton linters	pounds	173,000	Wrapping-paper	bundles	544
Sacks, empty	number	700	Sash, doors, and blinds, packages		680
Lumber	feet B. M.	1,050,000	Hardware	packages	9,519
Shingles	number	1,375,000	Groceries	packages	16,318
Ice	tons	1,450	Wooden ware	packages	1,092
Corn-meal	barrels	33,997			
Flour	barrels	16,999			

RECAPITULATION FOR NATCHEZ, MISSISSIPPI.

Total cargo received and shipped (tons)	$104.424
Total value of cargo received and shipped	2,951,362

VIDALIA, LOUISIANA.

Number of steam-boats in trade	21
Number of times they have landed	619
Number of barges	1
Total cargo received and shipped (tons)	10,419
Total value of cargo received and shipped	725,355

ARTICLES OF CARGO.

Cotton	bales	11,740	Miscellaneous	packages	3,564
Cotton-seed	sacks	51,140	Meat, salt	boxes	228
Cross-ties	number	14,220	Furniture	packages	1,284
Bran	sacks	420	Sugar	barrels	272
Corn	do	6,584	Molasses	do	160
Oats	do	6,056	Groceries	packages	972
Cornmeal	barrels	4,244	Lime	barrels	240
Flour	do	2,492	Hardware	packages	1,416
Hay	bales	720	Coal	bushels	25,000
Liquors	barrels	120	Lumber	feet B. M.	250,000

BAYOU SARA, LOUISIANA.

Receipts.

Number of steam-boats in the trade	54
Number of times they arrived	1,028
Number of barges	26
Total cargo arrived (tons)	50,717
Value of same	$1,589,979

ARTICLES OF CARGO.

Cotton	bales	9,000	Screenings	sacks	8,000
Coal	bushels	562,500	Grits	barrels	11,120
Potatoes	barrels	3,500	Soda-pop	boxes	300
Corn-meal	do	37,835	Groceries	packages	25,000
Flour	do	14,697	Furniture	do	3,600
Pork	do	7,101	Hardware	do	6,000
Corn	sacks	30,000	Wooden ware	do	35,000
Oats	do	75,120	Molasses	barrels	400
Meat, salt	pounds	1,200,000	Sugar	do	2,000
Soap	do	15,000	Coffee	sacks	1,750
Lard	do	75,000	Rice	barrels	500
Beer	casks	6,000	Salt	sacks	1,500
Bagging	rolls	4,300	Tobacco	pounds	50,000
Ties	bundles	4,290	Miscellaneous	packages	6,250
Hay	bales	8,000	Fertilizers	tons	180
Lime	barrels	515	Wire	coils	5,000
Bran	sacks	6,000	Ice	tons	700

Shipments.

Number of steam-boats in the trade	48
Number of times departed	1,022
Total cargo shipped (tons)	20,083
Value of same	$1,696,199.00

ARTICLES OF CARGO.

Cotton	bales	27,000	Cement	barrels	25
Cotton seed	sacks	90,000	Bran	sacks	1,500
Lumber	feet B. M	626,000	Screenings	do	1,600
Potatoes	barrels	1,875	Grits	barrels	8,340
Corn-meal	do	9,458	Groceries	packages	3,125
Flour	do	3,677	Furniture	do	900
Pork	do	1,775	Hardware	tons	50
Corn	sacks	7,500	Wooden-ware	packages	3,509
Oats	do	18,780	Molasses	barrels	200
Meat, salt	pounds	300,000	Sugar	do	500
Soap	do	3,750	Coffee	sacks	437
Lard	do	18,750	Rice	barrels	250
Bagging	rolls	1,078	Salt	sacks	375
Ties	bundles	1,078	Tobacco	pounds	8,333
Hay	bales	6,000	Miscellaneous	packages	1,560
Lime	barrels	178	Wire	coils	1,250

RECAPITULATION FOR BAYOU SARA, LOUISIANA.

Total cargo received	tons	20,083.00
Total value of same		$1,696,199.00
Total cargo shipped	tons	50,717.00
Total value of same		$1,589,979.00
Total cargo received and shipped	tons	70,800.00
Total value of same		$3,286,178.00

BATON ROUGE, LOUISIANA.

Receipts.

Number of steam-boats in the trade	53
Number of times they arrived	872
Number of barges	97
Total cargo received	138,170
Total value of same	$1,820,976.00

Articles of cargo.

Cotton	bales	2,000	Liquors	barrels	66
Cotton seed	tons	2,397	Wrapping-paper	bundles	594
Lumber	feet, B. M.	11,528,000	Hardware	packages	20,402
Coal	bushels	2,182,500	Groceries	do	352,032
Potatoes	barrels	14,750	Wooden-ware	do	2,030
Corn-meal	do	37,150	Miscellaneous	do	5,131
Flour	do	18,575	Bagging	rolls	2,000
Oats	sacks	66,870	Ties	bundles	5,720
Corn	do	37,240	Sugar	barrels	1,880
Bran	do	7,448	Molasses	do	1,720
Hay	bales	7,600	Rice	do	1,380
Pork and mess beef,	barrels	745	Coffee	sacks	1,220
Vinegar	do	136	Tobacco	pounds	200,000
Oils	do	241	Dry goods	packages	1,800

Shipments.

Number of steam-boats in the trade	49
Number of times departed	864
Total cargo shipped tons	33,436
Total value of same	$1,532,906

ARTICLES OF CARGO.

Cotton	bales	12,000	Pork and mess beef	barrels	298
Cotton-seed	sacks	32,600	Vinegar	do	54
Cotton-seed meal	do	8,700	Oils	do	96
Lumber	feet B. M.	4,650,000	Liquors	do	26
Shingles	number	350,000	Wrapping paper	packages	237
Brick	do	2,750,000	Hardware	do	8,160
Moss	bales	3,700	Groceries	do	20,812
Wool	pounds	10,000	Wooden-ware	do	12,812
Hides	number	44,200	Miscellaneous	do	2,052
Cabbage	crates	200	Bagging	rolls	800
Potatoes	barrels	6,250	Ties	bundles	2,288
Ice	tons	400	Sugar	barrels	2,377
Corn-meal	barrels	14,860	Molasses	do	3,388
Flour	do	7,430	Rice	do	542
Oats	sacks	26,748	Coffee	sacks	488
Corn	do	14,895	Tobacco	pounds	80,000
Bran	do	2,979	Dry goods	packages	720
Hay	bales	3,040			

RECAPITULATION FOR BATON ROUGE, LOUISIANA.

Total cargo received	tons	138,170
Total value of same		$1,820,976
Total cargo shipped	tons	33,436
Total value of same		$1,532,906
Total cargo received and shipped	tons	171,606
Total value of same		$3,353,882

PLAQUEMINE, LOUISIANA.

Number of steam-boats in the trade	52
Number of times they arrived	466
Number of barges	41
Total tonnage brought	52,781
Total value of same	$637,545

ARTICLES OF CARGO.

Receipts.

Potatoes	barrels	2,600	Coffee	sacks	1,220
Onions	do	780	Liquors	barrels	269
Corn-meal	do	7,566	Vinegar	do	188
Flour	do	10,088	Oils	do	279
Grits	do	2,275	Dry goods	packages	1,170
Hay	bales	1,235	Miscellaneous	do	2,358
Corn	sacks	8,970	Lime	barrels	792
Oats	do	14,950	Pork and beef	do	396
Bran (wheat)	do	2,795	Meat (salt)	boxes	1,092
Bran (rice)	do	1,560	Fruits	packages	1,080
Groceries	packages	49,355	Oysters	barrels	2,160
Hardware	do	3,257	Machinery	tons	32
Wooden-ware	do	1,497	Crockery	packages	184
Sugar	barrels	1,352	Furniture	do	1,560
Molasses	do	312	Coal	bushels	1,055,203
Rice	do	1,040			

Shipments.

Number of steam-boats in the trade	55
Number of times they departed	414
Number of barges	6
Tonnage shipped	41,124
Value of same	$645,500

ARTICLES OF CARGO.

Lumber	feet, B. M.	10,075,000	Hides (loose)	number	19,000
Shingles		89,000,000	Fish	pounds	12,000
Sugar	hogsheads	1,000	Potatoes	barrels	1,600
Molasses	barrels	4,000	Onions	do	350
Moss	bales	5,000	Honey	do	50

RECAPITULATION FOR PLAQUEMINE.

Total cargo received	tons	52,781
Value of same		$637,545
Total cargo shipped	tons	41,124
Value of same		$645,500
Total cargo received and shipped	tons	93,905
Total value of same		$1,283,045

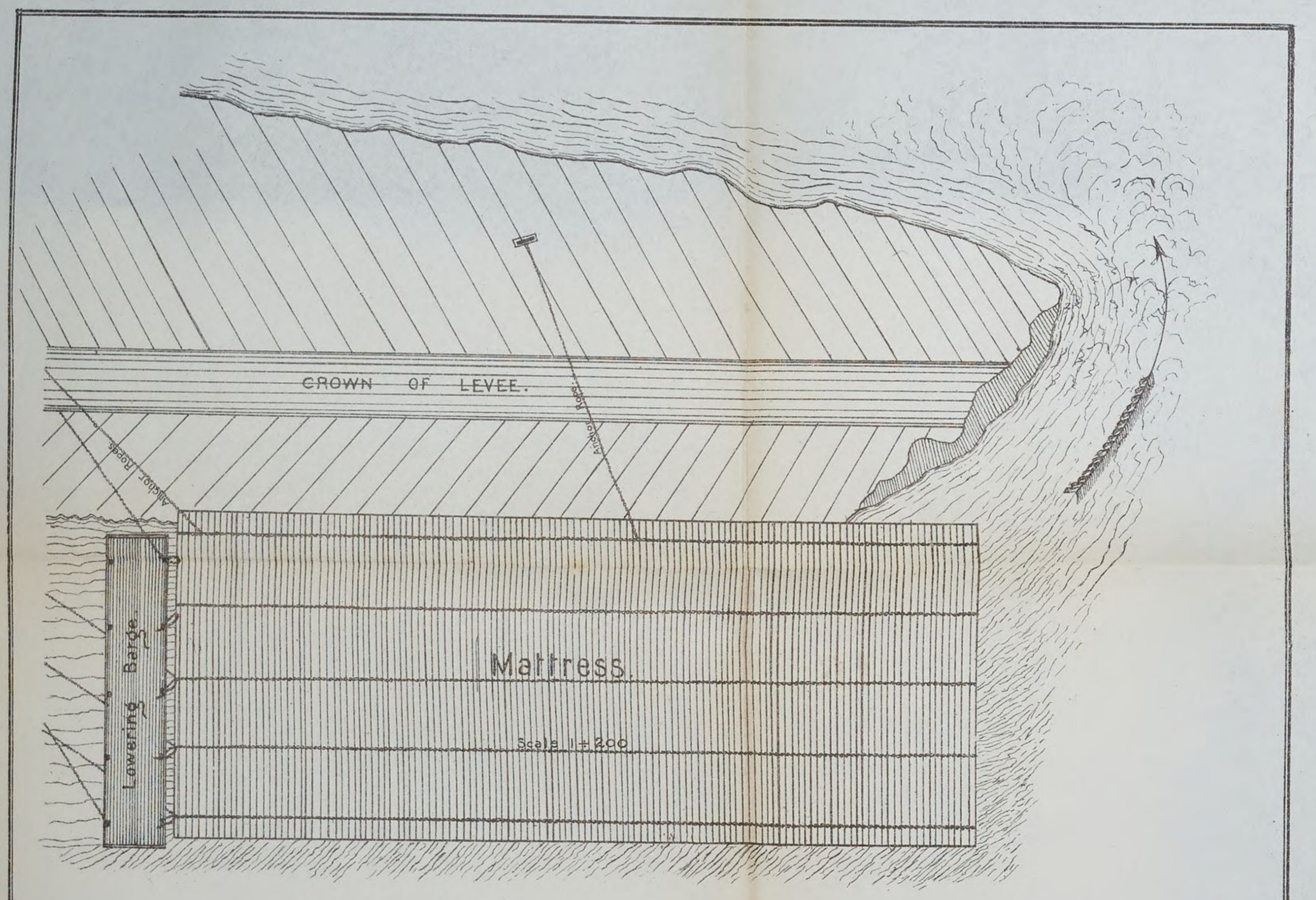
DONALDSONVILLE, LOUISIANA.

Receipts.

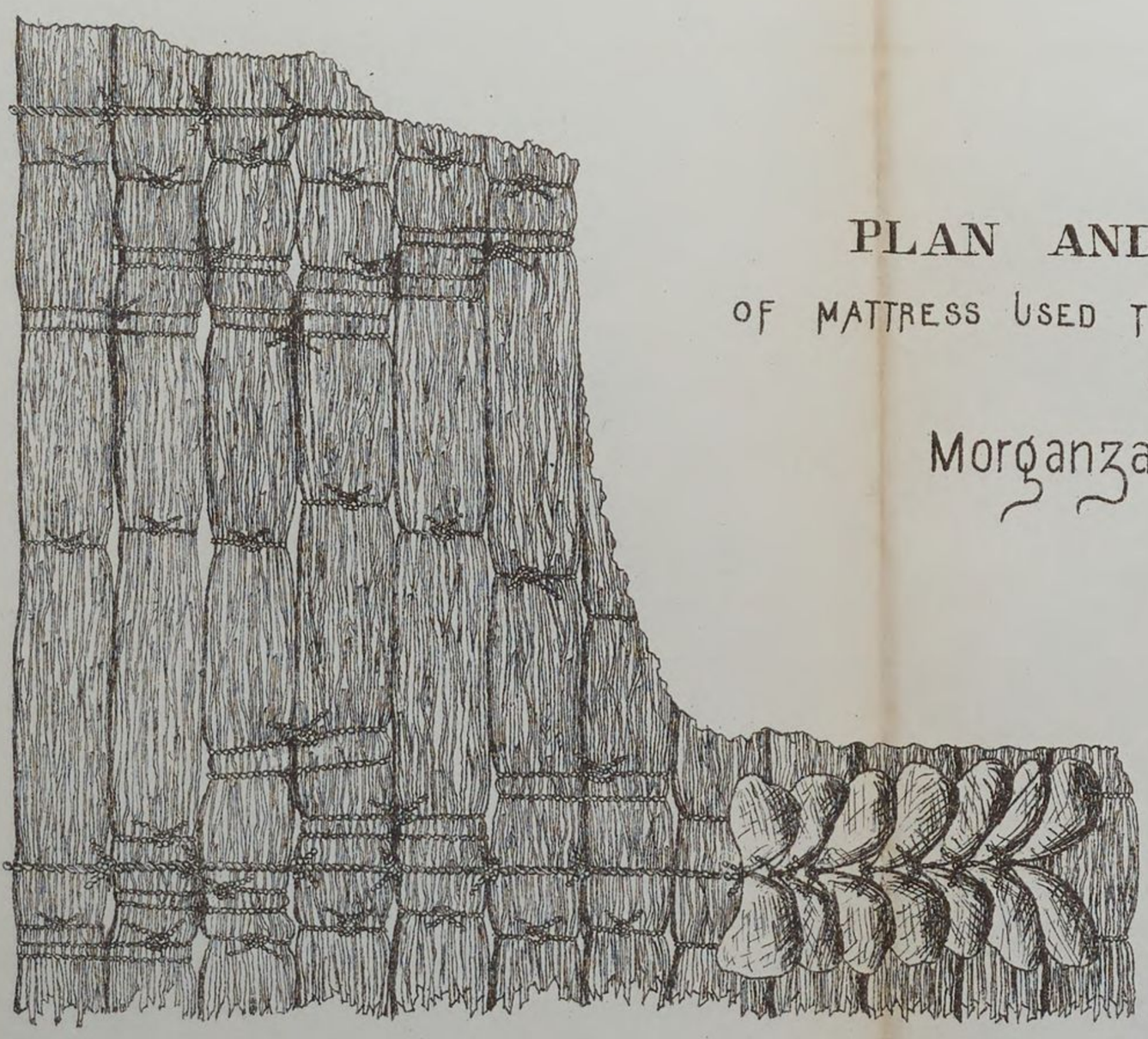
Number of steam-boats in the trade		40
Number of times they arrived		946
Number of barges		80
Total cargo received	tons	84,969
Total value of same		$669,325

ARTICLES OF CARGO.

Corn-meal	barrels	2,070	Crockery	packages	2,790
Flour	do	4,565	Lime	barrels	800
Grits	do	1,742	Miscellaneous	packages	1,990
Meat (salt)	boxes	1,040	Fruits	do	1,640
Liquors	barrels	686	Oysters	barrels	1,950
Oils	do	1,030	Onions	do	1,140
Vinegar	do	103	Lumber	feet, B. M.	85,000
Corn	sacks	10,400	Potatoes	barrels	2,850
Oats	do	26,000	Acids	carboys	300
Hay	bales	2,080	Wood	cords	1,200
Bran (wheat)	sacks	1,560	Coal	bushels	1,836,000
Bran (rice)	do	2,300	Sugar	barrels	1,040
Groceries	packages	41,000	Molasses	do	520
Hardware	do	2,290	Rice	do	1,560
Wooden ware	do	1,420	Coffee	sacks	2,080
Dry goods	do	1,148			



SCALE 1 ÷ 30.



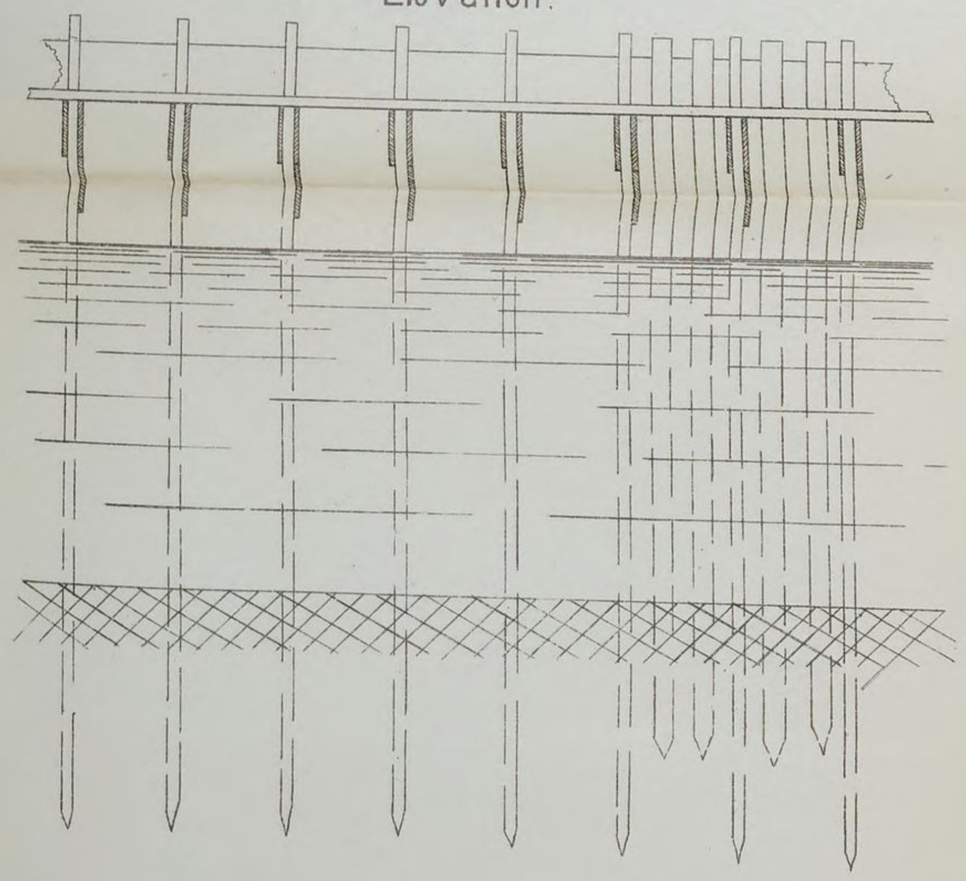
PLAN AND SECTIONS

OF MATTRESS USED TO PROTECT THE SOUTH END

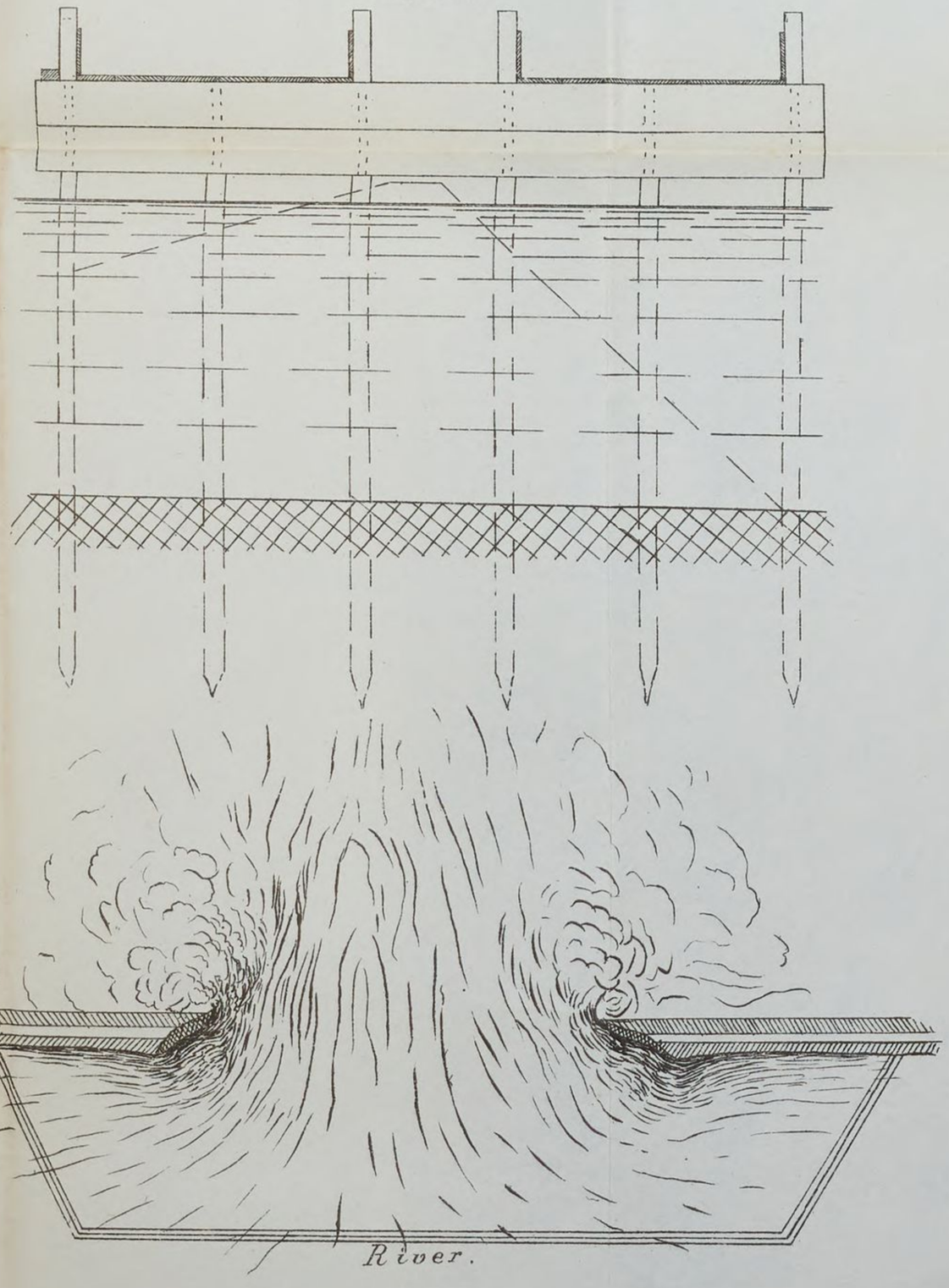
of

Morganza Crevasse.

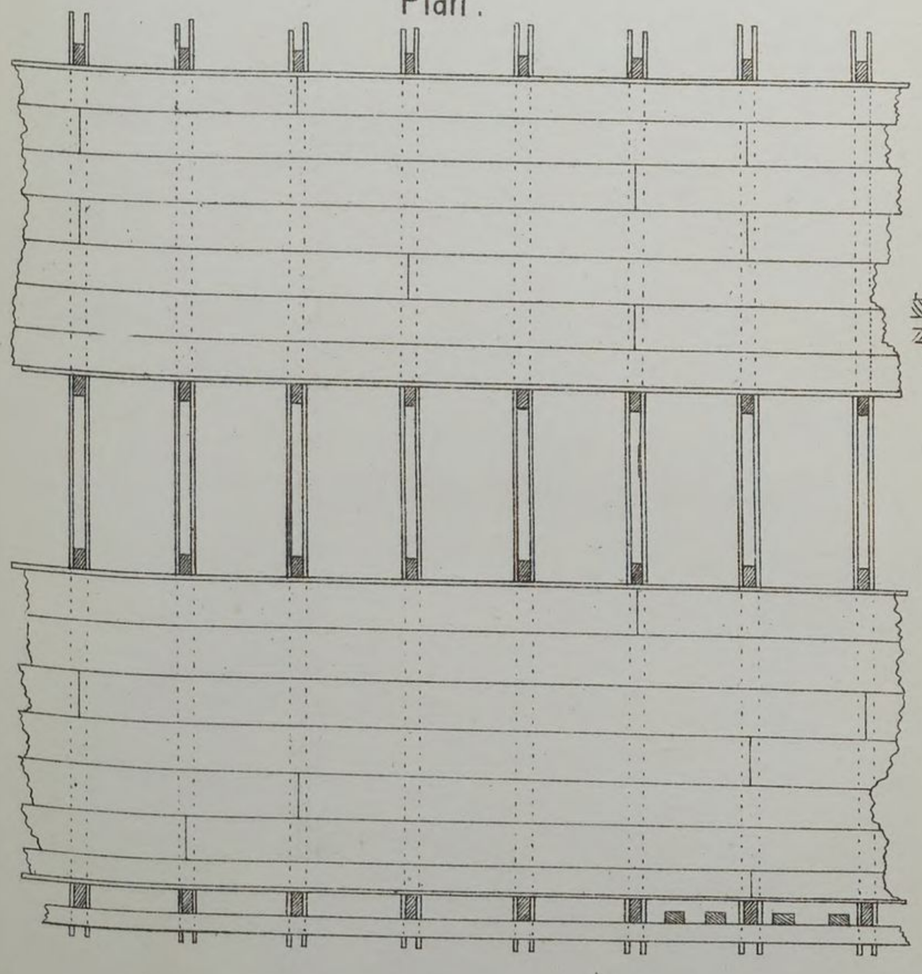
Elevation.



Section.



Plan.



Plan, Section and Elevation

OF STRUCTURE, USED IN CLOSING CREVASSES

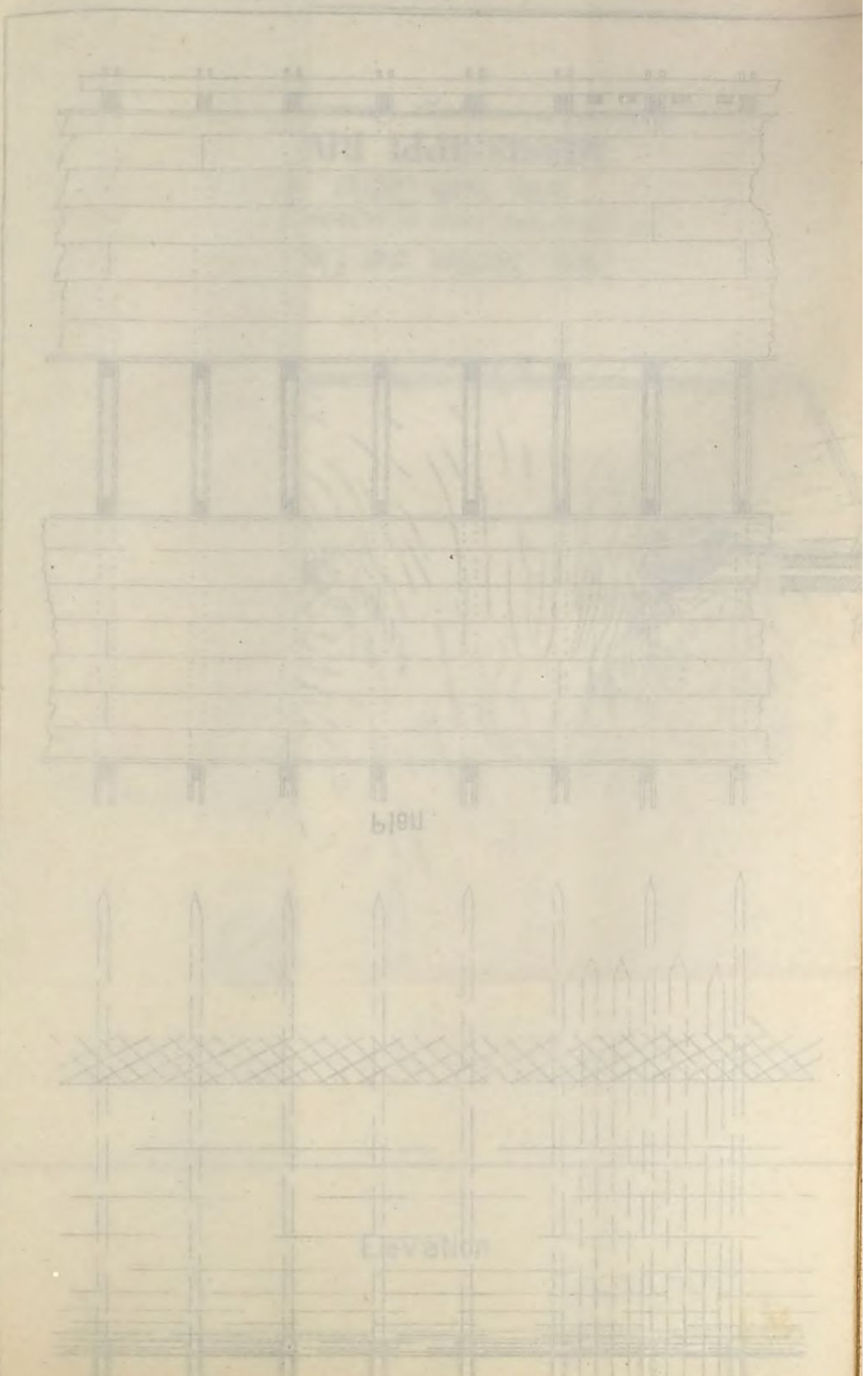
in the Fourth District,

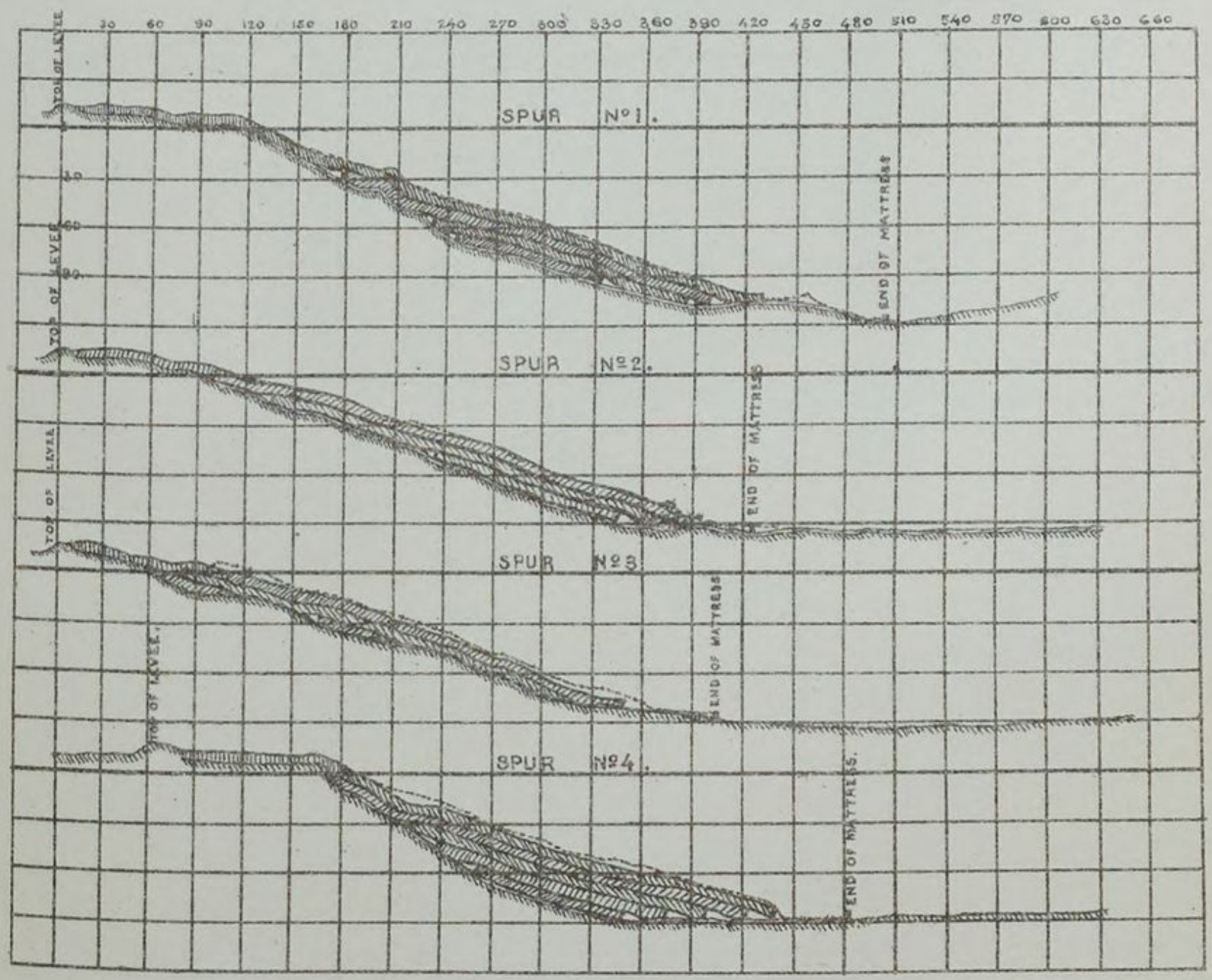
MISSISSIPPI RIVER.

Prepared to accompany Annual report of June 10th 1890.

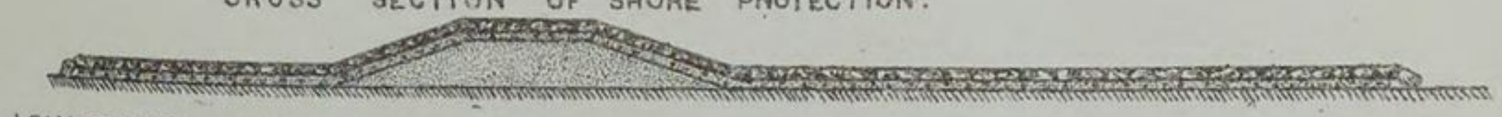
Dan'l Sheppard

Captain of Engrs U.S.A.

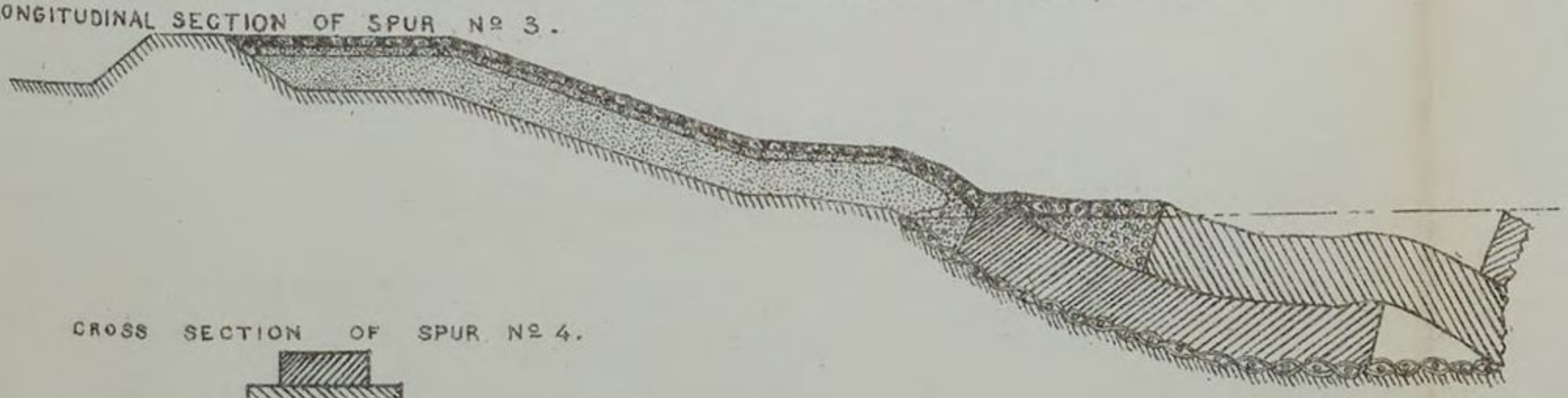




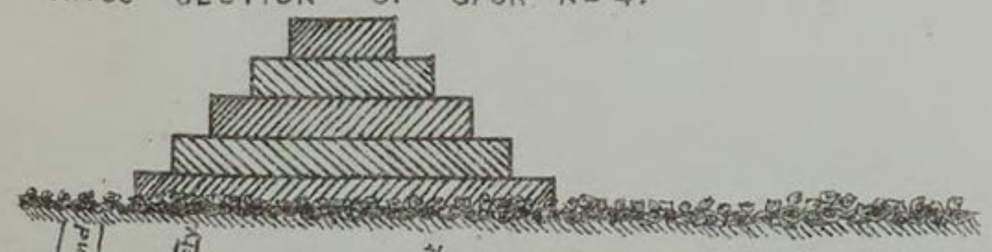
CROSS SECTION OF SHORE PROTECTION.

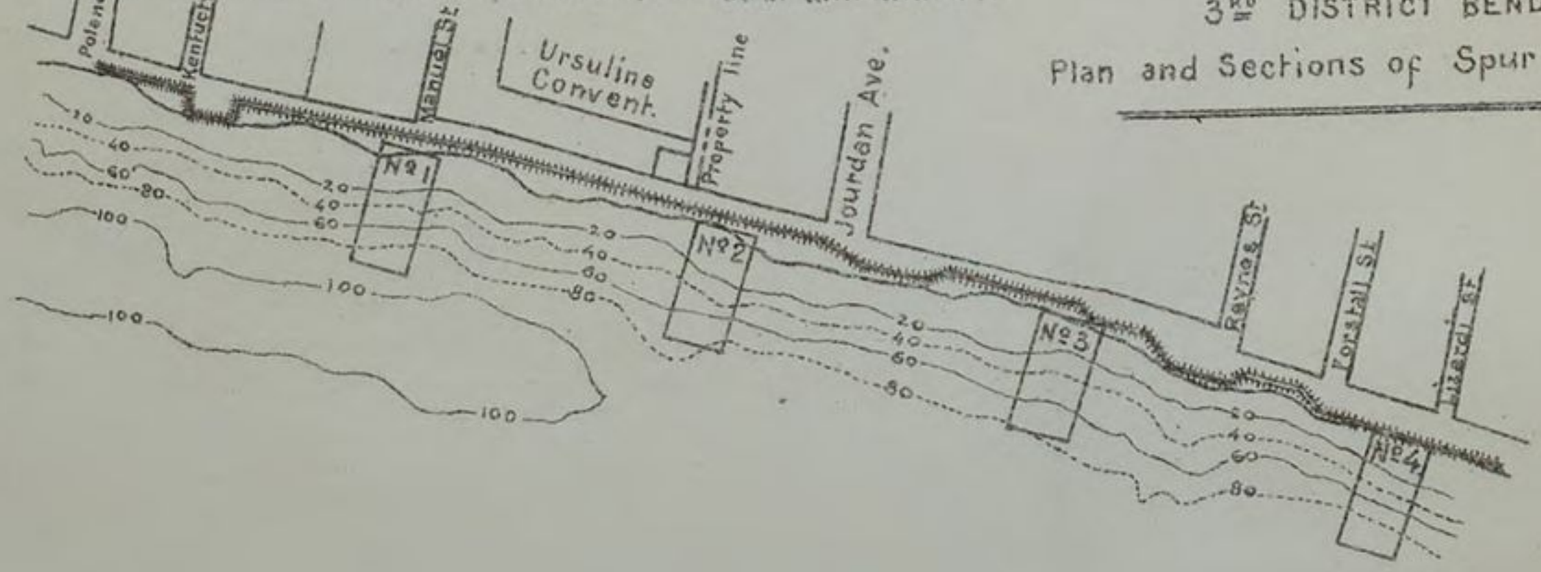


LONGITUDINAL SECTION OF SPUR Nº 3.



CROSS SECTION OF SPUR Nº 4.





NEW ORLEANS HARBOR.

3RD DISTRICT BEND.

Plan and Sections of Spur Dikes.

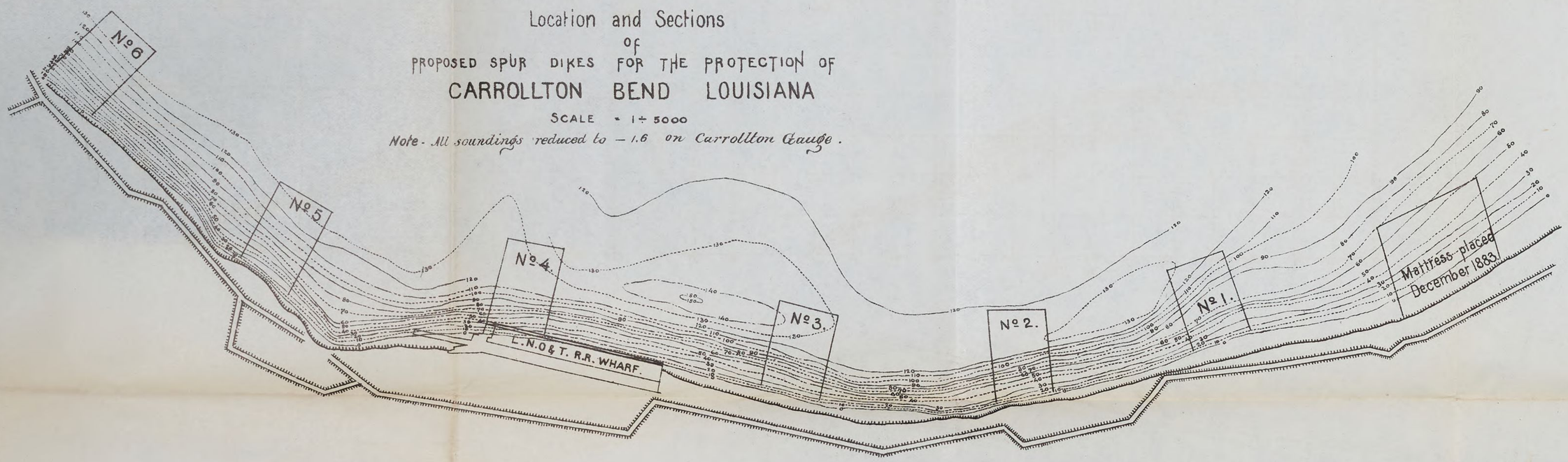
Eng 90

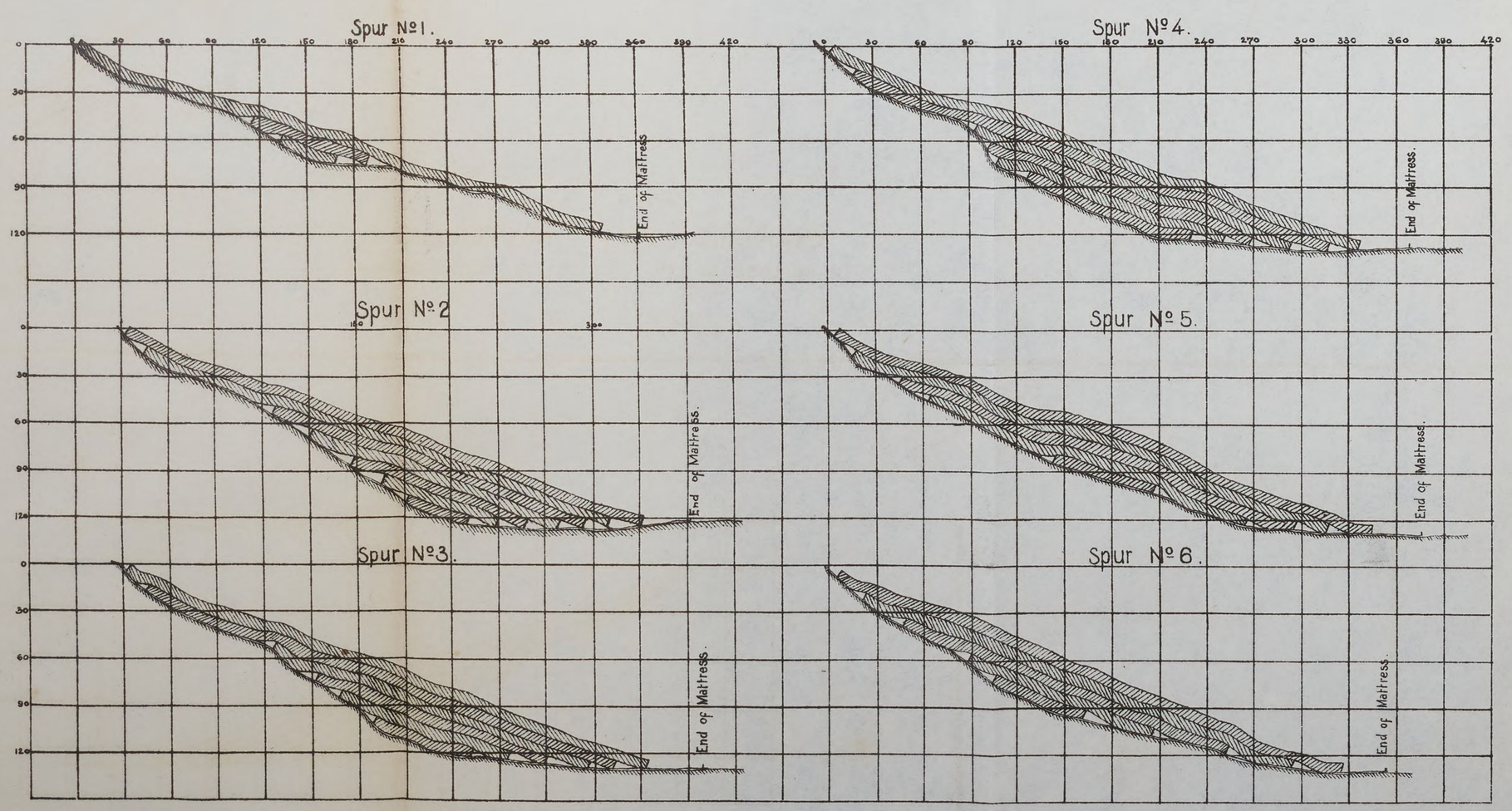


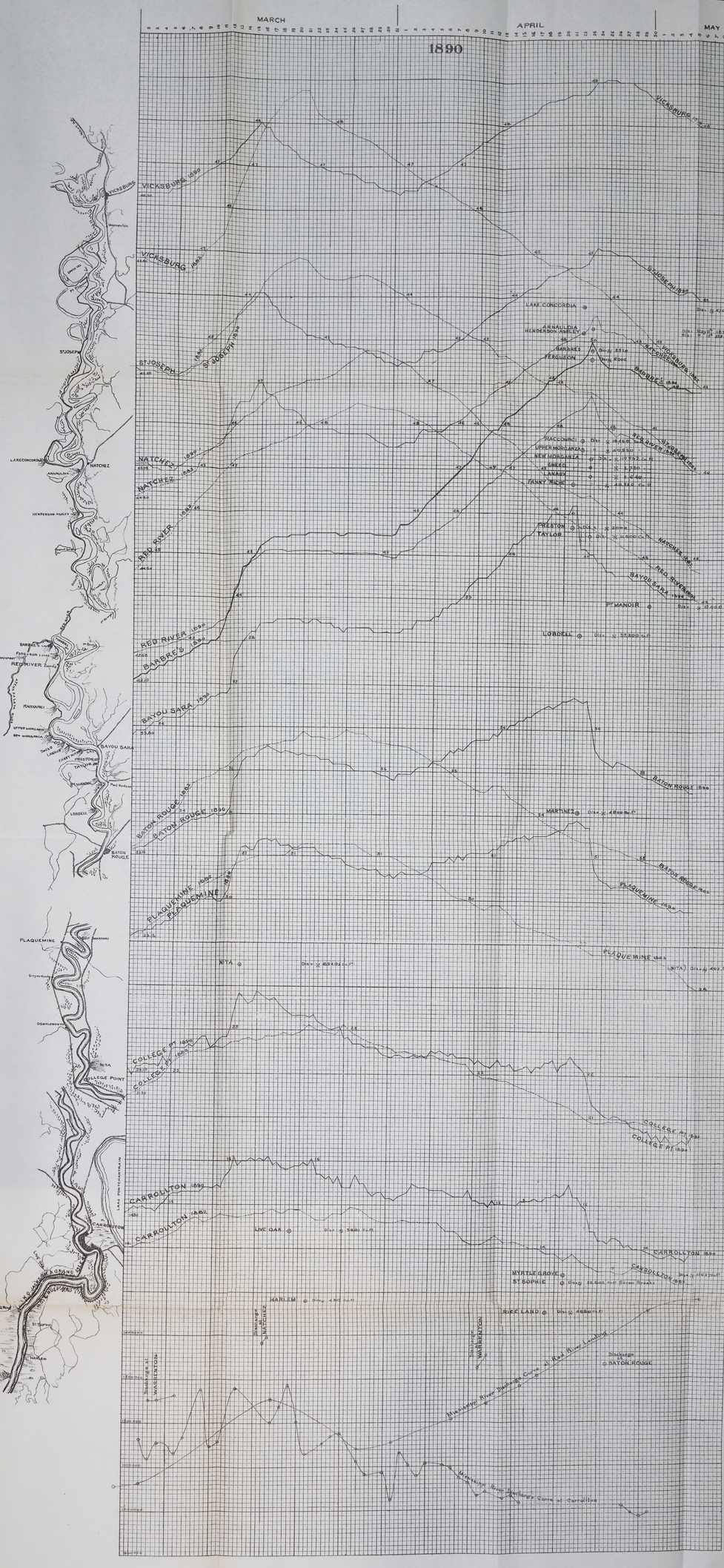
Location and Sections
of
PROPOSED SPUR DIKES FOR THE PROTECTION OF
CARROLLTON BEND LOUISIANA

SCALE = 1÷5000

Note - All soundings reduced to — 1.6 on Carrollton Gauge.







Comparative Gauge Heights

In the Fourth District

MISSISSIPPI RIVER

during the flood of 1890.

Prepared to accompany annual report of June 16th 1890

Dan C. Kingman

Capt. Corps of Engrs. U.S.A.



Shipments.

Number of steam-boats in the trade	27
Number of times they departed	742
Total cargo shipped ..... tons..	1,435
Value of same	$135,250

ARTICLES OF CARGO.

Sugar	barrels..	6,600	Hides	number..	250
Molasses	do....	2,100	Miscellaneous	packages..	2,650

RECAPITULATION FOR DONALDSONVILLE, LOUISIANA.

Tonnage received	84,969
Value of same	$669,325
Tonnage shipped	1,435
Value of same	$135,250
Total tonnage received and shipped	86,404
Total value of same	$804,575

APPENDIX XX.

ANNUAL REPORT OF THE MISSOURI RIVER COMMISSION FOR FISCAL YEAR ENDING JUNE 30, 1890.

MISSOURI RIVER COMMISSION,
St. Louis, Mo., July 21, 1890.

SIR: The Missouri River Commission beg leave to submit herewith their annual report for the fiscal year ending June 30, 1890.

At the date of the last report of the Commission work was actively in progress at various points along the Missouri River. These operations have been in progress during the past year and are now practically completed.

For convenience of reference the special appropriations and allotments under the act of August 11, 1888, are repeated here.

Specific appropriations:		
Sioux City, Iowa		$100,000
Omaha, Nebr		150,000
Plattsmouth, Nebr		50,000
Nebraska City, Nebr		75,000
Rulo, Nebr		50,000
St. Joseph, Mo		65,000
Atchison, Kans		75,000
Leavenworth, Kans		75,000
Kansas City, Mo		65,000
Miami, Mo		25,000
Arrow Rock, Mo		45,000
Total		775,000
Allotments of Commission:		
Improvements above Sioux City	$50,000	
Surveys above Sioux City	50,000	
Surveys below Sioux City	35,000	
Removal of obstructions	45,000	
Kansas City, Mo	45,000	
		225,000
Total		1,000,000

SURVEYS AND EXAMINATIONS.

The secondary triangulation of the Missouri Valley was carried on during the past season by two parties. One party, beginning at Trover's Point, Montana, carried the work to Bismarck, N. Dak., at which point the second party began, closing their season's work at Sioux City, Iowa. The work of the two parties covered during the season, subsequent to July 1, about 907 miles of river. There still remains a gap of 385 miles between Sioux City and Fort Leavenworth, Kans. A party

is now in the field which will close this gap during the present season. The triangulation will then be continuous from the mouth to Fort Benton.

Another party is now engaged in locating permanent bench-marks between Sioux City and Fort Leavenworth. A small party was engaged during the past season in making a topographical survey between Fort Benton, Mont., and the Coal Banks, a distance of 40 miles. They are again in the field this year, and it is hoped to carry their work to Trover's Point, Montana, this season. This will leave to be completed topography from Trover's Point, Montana, to Pierre, S. Dak., and permanent bench-marks from Trover's Point to Sioux City, Iowa. It is hoped that the pending river and harbor bill will allow of the completion of this work.

Above Fort Benton the topography and levels have been carried in former years from Stubbs's Ferry to the mouth of Sun River. It is now proposed, with the appropriation made for the surveys in this part of the river in the act of July 5, 1884, to complete this work between the Three Forks and Stubbs's Ferry, and between the mouth of Sun River and Fort Benton, and to carry the triangulation and permanent bench-marks over the whole distance. This, with the work before mentioned, below Fort Benton, will complete the survey of the Missouri River from Three Forks to its mouth.

Special surveys have been made at various localities where obstructions were complained of or where work was projected. Twenty-three gauges have been maintained and read, and much study has been given to the large collection of physical data in this office.

For details see report of secretary of the Commission, Appendix A.

WORK BETWEEN FORT BENTON, MONTANA, AND SIOUX CITY, IOWA.

This was confined to the rocky portion of the river between Fort Benton and Carroll, and consisted in the closure of chutes, narrowing the channel by wing-dams, and dredging at six different places. The party also carried a survey from Fort Benton to the Coal Banks, about 40 miles, and are now extending the same. This work was in charge of First Lieut. H. M. Chittenden, Corps of Engineers, U. S. Army. (See Appendix B for details.)

WORK BETWEEN SIOUX CITY, IOWA, AND THE MOUTH OF THE MISSOURI RIVER.

For details see Appendices C, C 1, D, and E.

Sioux City, Iowa.—The work at this point, under a special appropriation, was designed to check the erosion of the low ground in front of the city. The system of pile-dikes put in for this purpose, and described in the last report, has answered the purpose intended although the very low stage of water which has prevailed has not given as extensive accretions as may ultimately be expected. No repairs have been as yet needed, and the balance remaining on hand will probably suffice for any that may become necessary hereafter.

Omaha, Nebraska.—This work was also done under a special apppropriation. It consisted in protecting, by revetment, 13,000 feet of the left bank of the Missouri River below the Chicago and Northwestern dikes, the head of the work being about 6 miles above Omaha. This work was begun last fall and has just been completed.

Plattsmouth, Nebraska.—A small special appropriation was made for this place, but, as stated in their last report, the Commission have been unable to find any piece of needed work which could be accomplished with so small a sun. The appropriation, therefore, is still unexpended.

Nebraska City, Nebraska—The special appropriation for this place has been partly expended in revetting the shore-line of Nebraska City Island immediately above the railroad bridge which crosses the river at that point; 4,810 feet of work have been constructed. To render the work safe about 2,500 feet additional will be needed, and the balance still available will be held for this purpose.

Rulo, Nebraska.—This was also a special appropriation and it has been expended in constructing 4,900 feet of revetment in the upper portion of the bend above the town. The work has just been completed.

St. Joseph, Missouri.—Under the special appropriation for this place the last 2,200 feet of the revetment of the left bank in Bon Ton Bend has been completed during the past season.

Atchison, Kansas.—This work had been completed at the date of the last report and was fully described there. The works put in under a special appropriation, to control the approach to the bridge, have answered perfectly the purpose intended, although the prevailing low water has not been favorable for this sort of work.

Leavenworth, Kansas.—The special appropriation for this place has been expended in the construction of 6,658 feet of revetment on the left bank in Bee Creek Bend, above Fort Leavenworth. The work was done in the fall of 1889.

Kansas City, Missouri.—The work at this point was carried on partly under a special appropriation and partly under an allotment by the Commission. It had nearly all been completed at the date of last report. During the current season the point opposite the mouth of the Kaw River has been revetted, and some repairs and extensions have been made to the system of dikes below Kansas City and Harlem. Both of these systems and also the one in Little Platte Bend have been exceedingly successful in their operation, although the stage of water has been too low to secure the effects which may ultimately be expected.

Miami, Missouri.—The special appropriation for this place was expended this spring in constructing a system of pile-dikes below the town to stop erosion in that vicinity. They have just been completed and their effect can not as yet be foretold.

Arrow Rock, Missouri.—The special appropriation for this place was expended last fall in constructing 4,000 feet of revetment on the left bank of Nigger Bend, between Lisbon and Arrow Rock.

REMOVAL OF OBSTRUCTIONS.

The snag-boat belonging to the Commission resumed work in Missouri River August 30, 1889. Operations were carried on between the mouth and St. Aubert's, Mo., 127 miles. October 14 the boat was laid up, the allotment for this work being about exhausted. February 22, 1890, a special appropriation of $75,000 for continuing this work was made. As soon as possible the boat was started out again, entering Missouri River March 18, 1890. By May 31 she had worked up to Parkville, Mo., 398 miles and then started down-stream. June 16 she reached St. Louis, and the water being too high for good service she was laid up. As soon as the water falls sufficiently the work will be resumed.

Table of work done by snag-boat.

Name of river.	Snags destroyed.		Trees cut.	Drift-piles removed.	Miles run.
	Number.	Estimated weight in tons of 2,000 pounds.			
Mississippi	.....	.....	.....	.....	214
Missouri	1,575	15,945.9	1,048	8	1,189
Total	1,575	15,945.9	1,048	8	1,403

The funds in the hands of the Commission are now practically exhausted and but little work can be done till after the pending river and harbor bill passes. For this reason no projects for future work can be given. Estimates for continuing the general work are submitted.

Estimates for continuing works of improvement for the fiscal year ending June 30, 1892.

Salaries of Commission, office, and traveling expenses, surveys, and observations, gauges, etc	$150,000
River above Sioux City	175,000
River below Sioux City	1,100,000
Total	1,425,000

Money statement.

July 1, 1889, amount available		$589,493.71
Balance remaining of appropriation for removing obstructions from the Missouri River (act of August 5, 1886)		1,982.80
Amount appropriated by public resolution No. 10, approved February 22, 1890, for removal of snags and other obstructions in the Missouri River between St. Joseph, Mo., and its mouth		75,000.00
Cash received from sales of fuel to officers		9.75
		666,486.26
July 1, 1890, amount expended during the fiscal year exclusive of outstanding liabilities	$432,766.37	
July 1, 1890, outstanding liabilities	28,923.88	
		461,690.25
Balance		204,796.01
Deduct amount reserved for disbursement in Office Chief of Engineers, U. S. Army		1,696.00
July 1, 1890, balance available		203,100.01

Respectfully submitted.

CHAS. L. SUTER,
Lieut. Col. of Engineers, U. S. A.,
President Missouri River Commission.
A. MACKENZIE,
Major of Engineers, U. S. A.
O. H. ERNST,
Major of Engineers, U. S. A.
GARLAND C. BROADHEAD,
WILLIAM J. BROATCH.

The SECRETARY OF WAR.
(Through the Chief of Engineers, U. S. A.)

Financial statement from July 1, 1889, to June 30, 1890.

Work.	Appropriations.					
	Act of July 5, 1884.	Act of August 5, 1886. Amount available July 1, 1889.	Act of August 11, 1888. Amount available July 1, 1889. (Allotments.)	Act of February 22, 1890.	From sale of fuel to officers.	Totals.
In charge of secretary.						
Survey of the Missouri River above the Missouri River Falls at Fort Benton	$15,000.00					$15,000.00
Improving Missouri River from mouth to Fort Benton:						
Expenses proper of Commission gauges and physical data			$20,111.12		$9.75	20,120.87
Survey of Missouri River between Sioux City and mouth			21,405.18			21,405.18
Survey of Missouri River between Fort Benton and Sioux City			32,695.85			32,965.85
In charge of president.						
Removing obstructions from the Missouri River		$1,982.80				1,982.80
Removing obstructions in Missouri River from St. Joseph, Mo., to mouth				$75,000.00		75,000.00
Improving Missouri River from mouth to Fort Benton:						
Removal of snags and other obstructions			9,021.38			9,021.38
Repairs and care of plant			11,677.86			11,677.86
Kansas City, Mo			24,306.12			24,306.12
St. Joseph, Mo			33,658.20			33,658.20
Omaha, Nebr			105,486.22			105,486.22
Sioux City, Iowa			32,968.54			32,968.54
Plattsmouth, Nebr			40,498.06			40,498.06
Rulo, Nebr			39,998.06			30,998.06
Nebraska City, Nebr			56,837.29			56,837.29
Atchison, Kans			5,179.81			5,179.81
Leavenworth, Kans			57,347.64			57,347.64
Miami, Mo			20,112.36			20,112.36
Arrow Rock, Mo			36,101.54			36,101.54
In charge of First Lieut. H. M. Chittenden.						
Improving Missouri River from mouth to Fort Benton:						
Between Sioux City and Fort Benton			27,088.48			27,088.48
Total	15,000.00	1,982.80	574,493.71	75,000.00	9.75	666,486.26

Financial statement from July 1, 1889, *to June* 30, 1890—Continued.

Work.	Expenditures.			
	Amount expended during fiscal year, exclusive of outstanding liabilities.	Outstanding liabilities June 30, 1890.	Total.	Amount available July 1, 1890.
In charge of secretary.				
Survey of the Missouri River above the Missouri River Falls at Fort Benton	.....	.....	.....	$15,000.00
Improving Missouri River from mouth to Fort Benton:				
Expenses proper of Commission gauges and physical data	$15,994.55	$2,058.79	$18,053.34	2,067.53
Survey of Missouri River between Sioux City and mouth	1,232.59	2,865.74	4,098.33	17,306.35
Survey of Missouri River between Fort Benton and Sioux City	22,999.62	1,056.96	24,056.58	8,639.27
In charge of president.				
Removing obstructions from the Missouri River	1,982.80	.....	1,982.80	.....
Removing obstructions in Missouri River from St. Joseph Mo., to mouth	10,917.25	573.00	11,490.25	63,509.75
Improving Missouri River from mouth to Fort Benton:				
Removal of snags and other obstructions	9,021.38	.....	9,021.38	.....
Repairs and care of plant	8,874.56	.....	8,874.56	2,803.30
Kansas City, Mo	23,301.26	101.50	23,402.76	903.36
St. Joseph, Mo	29,010.50	199.02	29,209.52	4,448.68
Omaha, Nebr	*93,984.15	7,428.78	101,412.93	4,073.29
Sioux City, Iowa	*13,288.40	1,587.11	14,875.51	18,093.03
Plattsmouth, Nebr	936.28	.....	936.28	39,561.78
Rulo, Nebr	20,685.57	11,471.98	32,157.55	7,840.51
Nebraska City, Nebr	48,215.87	.....	48,215.87	8,621.42
Atchison, Kans	382.51	22.20	404.71	4,775.10
Leavenworth, Kans	55,029.95	929.97	55,959.92	1,387.72
Miama, Mo	18,744.80	233.83	18,978.63	1,133.73
Arrow Rock, Mo	35,754.82	.....	35,854.82	346.72
In charge of First Lieut. H. M. Chittenden.				
Improving Missouri River from mouth to Fort Benton:				
Between Sioux City and Fort Benton	24,105.51	395.00	24,500.51	2,587.97
Total	434,462.37	28,923.88	463,386.25	203,100.01

* Includes the sum of $1,696 reserved for expenses of the office of the Chief of Engineers, U. S. Army, as follows: Omaha, Nebr., $1,000; Sioux City, Iowa, $696.

List of civilian engineers employed on work of river and harbor improvement in charge of Missouri River Commission from July 1, 1889, *to June* 30, 1890, *inclusive, under the river and harbor act of August* 11, 1888.

[Improving Missouri River from its mouth to Fort Benton, Mont.]

Name and residence.	Time employed.	Compensation per month.	Where employed.
	Mo's. *D'ys.*		
G. A. Marr, St. Louis, Mo	5 0	$225.00	In the field.*
	7 0	200.00	St. Louis, Mo.*
O. B. Wheeler, St. Louis, Mo	5 15	225.00	In the field.*
	6 15	200.00	St. Louis, Mo*
S. Waters Fox, St. Joseph, Mo	12 0	200.00	St. Joseph, Mo.
Samuel H. Yonge, Kansas City, Mo	12 0	200.00	Kansas City, Mo.
Chas. F. Potter, Omaha, Nebr	12 0	200.00	Council Bluffs, Iowa, and Omaha, Nebr.
A. H. Blaisdell, St. Louis, Mo	11 21	200.00	St. Louis. Mo.

* On survey of Missouri River.

List of civilian engineers employed on work of river and harbor improvement in charge of Missouri River Commission, etc.—Continued.

Name and residence.	Time employed.	Compensation per month.	Where employed.
	Mo's. D'ys.		
Jas. A. Seddon, St. Louis, Mo	0 9	$200.00	St. Louis, Mo.
	2 20	150.00	Do.
	2 3	125.00	Do.
	1 6	100.00	Do.
D. W. Wellman, St. Louis, Mo	1 0	175.00	In the field.*
F. M. Towar, Detroit, Mich	12 0	175.00	Fort Benton and Omaha.
R. F. Grady, St. Louis, Mo	0 7	162.50	In the field.*
	6 23	125.00	Do.*
	1 0	122.00	Do.*
	4 0	115.00	St. Louis, Mo.*
J. J. Sanders, Craig, Mo	0 17	150.00	In the field.*
	4 13	125.00	Do.*
	6 0	100.00	St. Louis, Mo.*
Jos. C. Meredith, Atchison, Kans	12 0	150.00	Rulo and Nebraska City.
A. B. Ross, Omaha, Nebr	8 0	150.00	Council Bluffs, Iowa, and Omaha, Nebr.
	4 0	100.00	Omaha, Nebr.
D. C. Humphreys, Lexington, Va	2 0	150.00	St. Louis, Mo.*
E. E. Wall, St. Louis, Mo	0 18	137.50	In the field.*
	4 12	100.00	Do.*
	2 15	90.00	St. Louis, Mo.*
C. W. Williams, Sioux City, Iowa	0 18	130.00	In the field.
	4 8	100.00	Do.
Jas. F. Nutty, Omaha, Nebr	3 15	125.00	Fort Benton, Mont.
Karl A. Widen, St. Joseph, Mo	2 14	125.00	Omaha, Nebr.
F. M. Richardson, Omaha, Nebr	0 26	125.00	Do.
V. Schindler, St. Louis, Mo	12 0	125.00	St. Louis, Mo.
O. H. B. Turner, St. Louis, Mo	0 15	125.00	In the field.*
Frank Chrysler, Sioux City, Iowa	2 5	125.00	Do.*
B. C. Thayer, St. Joseph, Mo	3 8	125.00	Do.*
G. T. Nelles, Leavenworth, Kans	0 6	125.00	Do.*
O. Sonne, Kansas City, Mo	0 19	125.00	Do.*
A. H. Weber, Kansas City, Mo	11 23	125.00	Kansas City and Miami, Mo.
R. H. Bacot, Kansas City, Mo	11 0	125.00	Kansas City, Mo., and Leavenworth, Kans.
Ed. F. Hermans, Kansas City, Mo	3 18	125.00	Kansas City, Mo.
Reeves Smith, St. Paul, Minn	0 23	100.00	In the field.*
W. R. DeWitt, St. Joseph, Mo	0 13	100.00	Do.*
R. A. Crawford, Kansas City, Mo	0 10	100.00	Do.
F. A. Estelle, St. Louis, Mo	1 0	100.00	St. Louis, Mo.†
	0 22	90.00	Do.†
	1 0	80.00	Do.†
Allen T. Russell, St. Joseph, Mo	0 18	90.00	In the field.†
F. W. Lightner, Detroit, Mich	4 0	75.00	Fort Benton, Mont.
M. J. Lacy, Omaha, Nebr	4 0	75.00	Do.
Jos. Giesler, Fort Renton, Mont	1 0	75.00	Do.

* On survey of Missouri River. † On special survey.

APPENDIX A.

ANNUAL REPORT OF SECRETARY MISSOURI RIVER COMMISSION, 1889–'90.

OFFICE OF THE MISSOURI RIVER COMMISSION,
St. Louis, Mo., June 30, 1890.

SIR: I have the honor to submit the following annual report of the work in charge of the secretary of this Commission for the fiscal year ending June 30, 1890.

Very respectfully, your obedient servant,

JAMES C. SANFORD,
First Lieut. of Engineers, Secretary.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.
President Missouri River Commission.

This work was in charge of Capt. Theo. A. Bingham, Corps of Engineers, until January 9, 1890; in charge of the president of the Commission from January 9, 1890, to March 31, 1890; and since the latter date in my charge.

SURVEYS.

At the date of the last annual report, two parties were in the field, engaged in continuing the secondary triangulation of the Missouri River; one under Assistant Engineer O. B. Wheeler, working from Trover's Point, Mont., toward Bismarck, N. Dak.; the other, under Assistant Engineer G. A. Marr, working from Bismarck toward Fort Leavenworth, Kan. The first party at the above date were 150 miles below Trover's Point; the second, 160 miles below Bismarck.

Mr. Wheeler's party completed the triangulation to Bismarck, November 23. Since July 1, they had covered 442 miles of river distance (estimated), and had occupied seventy-nine stations. A base-line at Fort Buford was measured three times by day, when the sky was overcast. Azimuth observations for this base were made on five nights, and for the Bismarck base on two nights at the close of the season.

Mr. Marr's party completed the triangulation from Bismarck to Sioux City, Iowa, November 25. The river distance covered by them since July 1, was 465 miles (95 miles estimated, 370 taken from chart). Eighty-six stations were occupied. A base-line at Pierre, S. Dak., was measured five times, once at night and four times on cloudy days. A base-line at Running Water, S. Dak., was measured in parts—the longer part twice by day and three times by night; the shorter part four times by day and twice by night. Azimuth observations were made on two nights for both the Pierre and Running Water bases.

At the close of the season the quarter-boats used were hauled out and left in charge of watchmen—those of Mr. Wheeler's party at Rock Haven, near Mandan, N. Dak.; those of Mr. Marr's party, 3 miles above Sioux City.

The instruments used were the same as reported last year, except that the Gambey-Würdemann was replaced in July by the Troughton & Simms 12-inch theodolite of the Mississippi River Commission.

As stated in last year's annual report, six thermometers had been purchased for use with the tapes, and had been compared by the Signal Service with their standard-air thermometer in Washington. The results of this comparison are given in Mr. Wheeler's report of this year.

Full details of the season's work will be found in the reports of the assistants in charge, (Appendices A 5 and A 6).

Mr. Wheeler and Mr. Marr both speak highly of their assistants. Their own work is excellent and speaks for itself.

To complete the work of secondary triangulation from Fort Benton to the mouth of the river, there remained at the close of the season a gap of 385 miles between Sioux City and Fort Leavenworth, requiring sixty-eight stations to be built at places already located, in the fall of 1888, and seventy-two stations to be occupied.

In June, 1890, a party was organized and preparations made for completing this survey. The party, in charge of Assistant Engineer O. B. Wheeler, reached Sioux City June 17, and work of triangulation was at once begun. It is expected that they will complete the work during the present season.

At the close of 1889, a topographical survey of the Missouri River below Fort Benton, under charge of Lieutenant Chittenden, had been carried from Fort Benton to the Coal Banks, 40 miles. It was resumed in May, 1890; and it is hoped to carry it as far as Trover's Point, Mont., about 200 miles, during the present season. A gap of about 847 miles between Trover's Point and Pierre, S. Dak., will then be left to complete the survey from Fort Benton to the mouth. It is highly desirable to close this gap as soon as possible, in order to have a complete set of maps of the Missouri River to the practical head of navigation. The work could probably be done in one season, at an estimated cost, including the establishment of permanent level bench-marks over the same portion of river, of $70,000.

By resolution of June 24, 1890, the Commission recommended that "the $15,000 appropriated by act of Congress approved July 5, 1884, for survey of the Missouri River above the Missouri River Falls at Fort Benton, be made available for the survey contemplated by the act." The authority of the Secretary of War for this expenditure was given June 30, 1890. Preparations for the survey will be pushed as rapidly as possible, in the hope of completing it during the present season. It will be begun at the junction of the Three Forks of the Missouri River near Gallatin, Mont., and extend to Fort Benton, Mont., about 225 miles, there connecting with the surveys previously made from Fort Benton down. The work will consist of secondary triangulation, topography, and establishment of permanent bench-marks, and will be in charge of Assistant Engineer G. A. Marr. Considerable assistance will be derived from a survey made in 1880, from Stubb's Ferry to Sun River, 131.3 miles, under the direction of Captain (then Lieutenant) Edward Maguire, Corps of Engineers.

Special topographical surveys have been made during the year at Plattsmouth, Nebr.; from Randolph Bridge to Wellington, Mo.; from the head of Miller's Island to De Witt, Mo.; and from the head of Pinckney Bend to the foot of Emily Bend, Missouri.

GAUGES.

There have been twenty-three gauges maintained by the Commission and in direct charge of this office during the year, of which number seventeen are of the wire-cable pattern. All of the latter except one (at the St. Joseph Water Company's pump-house) are on bridges. At places having no bridges either inclined or vertical gauges, nearly all of them of wood, have been used. Some of these are temporary in construction, as they have to be moved whenever bars form in their front, or when the bank in their immediate vicinity caves. Frequent changes of gauge-site are unfortunate, as the varying factor of slope at different stages of the river, and with different conformations of shore and bar, is introduced. As new bridges are built, standard cable gauges will, for this reason, be established on them; and, if in the immediate vicinity of a shore-guage already established, the latter will be discontinued as soon as its readings can be equated with the permanent one.

All the gauges below and including Sioux City are now subjected to monthly inspection and testing by the respective division engineers. The results have proved very beneficial to the records, as any error that may now occur does not become cumulative.

The gauge on the Bismarck, N. Dak., bridge, being located beyond the limits to which Missouri River levels have been carried, its records are sent to the office giving heights above the zero adopted by the Northern Pacific Railroad Company.

Careful office supervision of records and inspection, including the platting of hydrographs weekly, has been carried on.

The stages of the river have been tabulated up to January 1, 1890, and cards giving the mean of the two daily readings, with the gauge histories, are ready for the printer. These are continuous with those published in House Ex. Doc. No. 28, Forty-ninth Congress, second session.

Considerable data regarding water stages at points on the river not occupied by the Commission's gauges has been secured from the Signal Service and from bridge companies. This also has been included in the above tabulation.

There is a deficiency of gauges in the upper river above Sioux City, and it is strongly recommended that a few be established at important points in this portion. Some changes in location could also be made to advantage among those below Sioux City, giving them a more favorable and equable disposition along the river.

It is proposed to provide observers with duplicate gauges, in order that loss of readings due to loss or breakage of gauges may be less liable to occur.

PHYSICAL DATA.

The work of collecting, arranging, and studying new data bearing on this subject has been continuous as far as the funds available would allow.

All of the data on file in the office relating to borings in the Missouri Valley has been compiled for publication, and is contained in the report on this subject appended. (Appendix A 2).

Compntations for slope and standard high and low water have been continued.

A table of ice closings and openings, embracing the winters of 1887–'88, 1888–'89, and 1889–'90, being additional to and consecutive with that given in the annual report of the secretary of the Commission for 1888, has been made out and is appended. (Appendix A 3.)

Assistant Engineer James A. Seddon has been engaged during a part of the year in an investigation of the relations between discharge and gauge readings. This involved the platting of all the principal gauge relations from Sioux City to St. Charles during the periods covered by reliable records; the determination of the normal relations of readings on the various gauges; the determination of standard curves and their transfer from point to point by the normal gauge relations, and the checking of such transfers with the observed discharges wherever taken. Considerable light was thrown on this subject by a preliminary study of the observations taken on the Upper Mississippi, under the Mississippi River Commission in 1880–'81.

The investigation is still in progress, but is well advanced, and will soon be made the subject of a special preliminary report.

PERMANENT LEVEL BENCH-MARKS.

The system adopted by the Commission for the establishment of permanent level bench-marks in lines is described in the Annual Report of the Chief of Engineers for 1889, page 2754. These lines are complete from Fort Benton, Mont., to Trover's

Point, Mont., and from Fort Leavenworth, Kans., to the mouth of the river. The bench-mark lines have also been put in from Iowa Point, Kans., to Atchison, Kans., a distance of 78 miles, but not yet connected with the triangulation.

During the present season it is proposed to establish the lines between Sioux City, Iowa, and Iowa Point, 306 miles, and to connect them, as well as those between Iowa Point and Atchison, with the triangulation to be made by Assistant Engineer Wheeler; the bench-mark party to follow the triangulation party for that purpose. Quarter-boats Nos. 5 and 6, which had been hauled out at Rock Haven, N. Dak., in the fall of 1889, and which it is intended to use in establishing bench-mark lines this season, were floated down from Rock Haven to Sioux City. The boats, in charge of Capt. C. B. Tilden, left Rock Haven May 20, and arrived at Sioux City June 19. The bench-mark party, under Assistant Engineer D. W. Wellman, reached Sioux City a few days later, and preparations for the work were at once begun.

In addition to the distance expected to be covered by this party, there remains a gap of about 1,215 miles, from Trover's Point to Sioux City, over which the system is to be extended. From Trover's Point to Pierre, S. Dak., the work can best be done in connection with the topographical survey, and its cost is included in the estimate given above for the latter work. From Pierre to Sioux City, 368 miles, the topography is already completed. An estimate of $15,000, or about $40 per mile, for the establishment of bench-mark lines along this portion of the river is submitted. The work can be done in one season. Nearly all the old bench-marks having disappeared, it is of the greatest importance that the new system should be completed without delay.

A table is appended (Appendix A 4) giving descriptions and elevations of Missouri River bench-marks established in 1888 and 1889, and not hitherto published.

COMMERCIAL STATISTICS.

Considerable work has been done during May and June in collecting commercial statistics. The time being limited, attention has been paid chiefly to ascertaining amount carried by river in the calendar year 1889, rather than to obtaining more varied but less complete and reliable information.

Circulars were sent to all owners of steam-boats on the river, and, in the majority of cases, were satisfactorily answered. A second circular was sent in some cases requesting that omissions in the reply to the first be supplied; and, as far as possible, such steam-boat owners as had not answered the circulars were visited in person. It is believed that the totals obtained represent very nearly the correct amount of commerce by the Missouri River in 1889.

Lists of steamers plying on the river in that year were furnished me by the surveyors of customs at St. Louis, Mo., Kansas City, Mo., St. Joseph, Mo., Omaha, Nebr., and St. Vincent, Minn. The steamers were registered at the remaining port of entry, Fort Benton, Mont. Reports of several boards of trade of Missouri River cities were furnished me by the secretaries.

A detailed commercial report is appended. (Appendix A 1.)

ESTIMATES.

Office and traveling expenses and salaries of Commission	$20,000
Surveys and observations	102,000
Physical data and publications	20,000
Gauges	8,000
Total	150,000

A 1.

REPORT ON THE COMMERCE OF MISSOURI RIVER DURING YEAR 1889.

MISSOURI RIVER COMMISSION,
St. Louis, Mo., June 30, 1890.

SIR: I have the honor to submit the following report on the commerce of the Missouri River during the calendar year 1889:

The time that could be devoted to collecting this information was so limited that full and complete statistics on all the various points of interest in connection with the subject could not be obtained. For this reason, it was decided to attempt little more than to obtain the amount carried by river in the calendar year 1889—the calen-

dar year being taken on account of the necessary inaccuracy and incompleteness of figures for the present fiscal year.

The names of all steam-boats enrolled at the custom-houses at St. Louis, Mo., Kansas City, Mo., St. Joseph, Mo., Omaha, Nebr., and St. Vincent, Minn., and believed to be plying on the Missouri in 1889, were first obtained from the surveyors of customs at those ports, as well as the names and addresses of owners, and certain other details given in the tables below. It was also ascertained that no steam-boats were enrolled in 1888 or 1889 at the custom-house at Fort Benton, Mont., the only remaining port whose district includes any portion of the river. Circulars were then sent to these steam-boat owners, requesting information in regard to their business. In these circulars it was stated that the information received as to particular boats would be considered confidential, and used only in making up totals. It was probably due to this that a majority of the circulars were answered. In cases where the answers were incomplete, a second circular was sent, asking that omissions be supplied. Finally, those steam-boat owners who had not answered the circulars, or whose answers were not sufficiently explicit, were, as far as practicable, visited in person, and they invariably furnished the desired information.

The following table shows the number and registered tonnage of the steam-boats on the Missouri River in 1888 and 1889:

Enrolled at—	1889.		1888.	
	No.	*Tons.*	*No.*	*Tons.*
St. Louis, Mo	16	1,812.66	16	2,493.66
Kansas City, Mo	15	1,626.26	12	1,085.67
St. Joseph, Mo	5	277.62	6	361.56
Omaha, Nebr	13	1,329.55	19	2,666.46
St. Vincent, Minn	8	1,852.08	11	2,408.67
Fort Benton, Mont	0	0.00	0	0.00
Total	57	6,898.17	64	9,016.02

These boats were employed as packets, making more or less regular trips; in a short-trip coasting trade, as tow-boats, wholly or partly as excursion boats, or as ferry-boats. As nearly all of them are used for a variety of purposes in the same year, it is exceedingly difficult to classify them in regard to nature of business.

The year 1889 is regarded by steam-boat men as an exceptionally bad one for their interests. The total enrolled tonnage for the year is believed to be less than for any year since 1850. Present indications, however, point to a considerable increase in 1890. During part of 1889 underwriters refused to insure any Missouri River steam-boats; and the rate of insurance, 18 per cent. on hulls, during the rest of the year was so high as to leave little profit to the boat-owners. The rates of insurance on cargoes were in 1888 made double the rates that had been current for many years before. These rates were, however, reduced one-fourth on July 1, 1889, in consequence of work done by the United States snag-boat. The small tonnage enrolled is largely due to the almost prohibitory insurance rates.

In addition to the steam-boats, a considerable number of flat-boats, barges, etc., are employed in river business. The surveyor of the port of Kansas City furnished me a list of seventy-three such boats, having an aggregate tonnage of 1,986 tons, as being in use in his district in 1889. I was unable to get similar lists from the other districts.

There was also a small amount of business done in rafting logs and railroad-ties during the year, but its amount has not been definitely ascertained.

The following represents the total amount carried or towed by steam-boats during the year:

Tons of freight	865,493
Number of passengers	332,218

The freight consisted mainly of grain, stock, wool, hides, miscellaneous farm produce, sand, lumber, cord-wood, and general merchandise.

NEW LINES OF TRANSPORTATION ESTABLISHED DURING THE FISCAL YEAR 1889–'90.

1. The most important new line of transportation on the Missouri River established during the year is the packet line between St. Louis and Kansas City, 404 miles, owned by the Kansas City and Missouri River Transportation Company. The following extract from a letter of Mr. A. L. Mason, president of the company, gives a good description of the line.

"KANSAS CITY, MO., *May* 22, 1890.

* * * * * * *

"In reply to your inquiries we beg to say:

"(1) Our line will consist of three steam-boats, each 250 feet long by 46 feet beam, with the main deck 250 by 52 feet over all; two of the boats will have holds 5 feet deep, while the third will be 5½ feet; the boats are all contracted for, and are now being built at Madison and Jeffersonville, Ind.

"(2) The custom-house tonnage has not yet been ascertained, but is estimated at about 800 tons each.

"(3) Their freight-carrying capacity will be 1,000 to 1,200 tons each. We will have eleven state-rooms, with one upper and one lower berth in each, with accommodations for from twenty-two to thirty passengers; the boats are designed to do a limited passenger business only.

"(4) It is expected that each boat will make about twenty-four round trips per full season between Kansas City, St. Louis, and East St. Louis, giving two departures per week, or nearly so, from each end of the line.

"(5) It is expected that the steamer *A. L. Mason* will be in service from St. Louis by June 15; steamer *State of Kansas* by July 15; steamer *State of Missouri* by August 15." * * *

The first boat of the line, somewhat delayed by high water in launching, has reached St. Louis, and expects to leave for Kansas City in a few days. Her measured tonnage proves to be greater than anticipated, being 1,130.34 tons.

The organization of the company is somewhat peculiar. The capital stock, $150,000, is held by between 300 and 400 shareholders, nearly all of whom are prominent business men, making large shipments between St. Louis and Kansas City, and no individual share-holder owns any consideral proportion of the stock. It is of course of great advantage to them that a river line, competing with the railroads, should be maintained; and they have established this line in the belief that, even should it not pay running expenses, it will still well repay them for their investment by the reduction in freight rates caused by its competition.

2. A company known as the Missouri River Ttransportation Company has been organized for the purpose of running a packet line between Bismarck, N. Dak., and Sioux City, Iowa, about 625 miles. Their first, and at present their only steamer, the *Chaska*, formerly the *Abner O'Neil*, of Wheeling, W. Va., began running in the spring of 1890. She has a tonnage of 197 tons, and is expected to make about two trips a month. I was informed by the agent of the company at Sioux City that a second steamer would probably be put on the line next season.

3. A small steamer—her estimated tonnage is 55 tons—has been built to run in local trade between Brunswick, Mo., and landings on the Missouri and Grand rivers. She is to ply between Brunswick and Frankfort, Cambridge and intermediate landings, on the Missouri, 25 miles, and between Brunswick and Bedford on the Grand, 40 miles, and is expected to make her first trip about July 4 of this year.

List of steamers plying on the Missouri River in the district of New Orleans enrolled at the port of St. Louis during the year 1889.

Name.	Where built.	Year.	Date of last inspection.	Length.	Breadth.	Depth.
				Ft. In.	*Ft. In.*	*Ft. In.*
A. W. Ewing	Manchester, Ohio	1875	Apr. 8, 1889			
Black Diamond	Portland, Mo	1886	May 11, 1839	72 5	14 4	2 3
Dora	Borrger's Landing, Mo	1882	Apr. 8, 1889	90 9	20 0	3 6
Frederick	Tuscumbia, Mo	1883	... do	94 4	14 3	3 0
Fawn	Hermann, Mo	1880	....do	91 4	19 1	3 4
John L. Ferguson	Grafton, Ill	1876	Oct. 24, 1889	111 6	26 6	3 6
May Bryan	Jeffersonville, Ind	1875	Nov. 22, 1889	115 0	28 0	4 5
Royal	Hermann, Mo	1984	Apr. 8, 1889	86 6	24 0	3 0
Vienna	Plattsmouth, Nebr	1879	....do	89 8	24 0	2 8
Static Fisher	Jeffersonville, Ind	1875	Apr. 9, 1889	122 0	28 8	4 6
Benton	Pittsburgh, Pa	1875	Aug. 10, 1889	197 0	33 0	5 0
Helena	Pittsburgh, Pa	1878	June 26, 1889	194 0	33 0	4 5
John R. Hugo	Evansville, Ind	1879	May 11, 1889	127 0	20 0	3 0
Pin Oak	Hermann, Mo	1888	Apr. 8, 1889	95 0	17 5	2 2
Albert S. Willis	Louisville, Ky	1888	Mar. 13, 1889	153 1	26 5	3 0
New Haven	Grafton, Ill	1882	Mar. 29, 1888	136 1	24 4	3 4

List of steamers plying on the Missouri River, etc.—Continued.

Name.	Capacity under tonnage deck.	Capacity between decks.	Total tonnage.	State-rooms.	Berths.	Passengers.		
						Permitted to carry.	First cabin.	Steerage or deck.
	Tons.	*Tons.*	*Tons.*					
A. W. Ewing			4.00			28	8	20
Black Diamond			18.40	3		16	6	10
Dora	54.20	26.88	81.08	1	4	20	8	12
Frederick	34.49	48.02	82.51		10	15		15
Fawn	49.73	23.27	73.00	3		50	20	30
John L. Ferguson	79.81		79.81					
May Bryan	97.40		97.40			50		50
Royal	44.82		44.82			20		20
Vienna	47.60	25.57	73.17			20		20
Static Fisher	106.52		106.52					
Benton	259.62	134.46	394.08	18	36	66	30	36
Helena	233.81	118.50	352.31					
John R. Hugo	68.16	68.72	136.88	5	9	40	10	30
Pin Oak	33.32	9.73	43.05			20		20
Albert S. Willis			132.99					
New Haven			92.64					

Name.	Engines (high pressure).			Boilers.						Licensed to run on—
	Number.	Diameter of cylinder.	Length of stroke of piston.	Number.	Length.	Diameter.	Kind of material.	When built.	Steam pressure.	
		In.	*Feet.*		*Ft.*	*Ft.*			*Lbs.*	
A. W. Ewing	2	6	$\frac{3}{4}$	1	3	$3\frac{1}{3}$	Steel	1885	125	Mississippi River and tributaries
Black Diamond	2	6	3	1	14	3	Steel	1886	130	Do.
Dora	2	7	$2\frac{5}{8}$	1	18	$3\frac{1}{2}$	Steel	1882	120	Do.
Frederick	2	7	$2\frac{1}{2}$	1	14	3	Iron	1883	150	Do.
Fawn	2	8	2	1	14	$3\frac{1}{2}$	Iron	1887	110	Do.
John L. Ferguson	2	11	4	1	16	$3\frac{1}{2}$	Iron	1864	100	Missouri River between St. Charles and opposite shore.
May Bryan	1	16	5	1	22	$3\frac{3}{3}$	Iron	1875	113	Missouri River between Hermann and St. Charles.
Royal	2	8	$2\frac{1}{3}$	1	12	3	Steel	1884	125	Mississippi River and tributaries.
Vienna	2	8	$1\frac{1}{6}$	1	12	$3\frac{1}{3}$	Iron	1879	110	Do.
Static Fisher	1	$16\frac{1}{2}$	5	1	23	$3\frac{1}{2}$	Steel	1875	130	Between Jefferson City and Cedar City.
Benton	2	16	5	3	24	$3\frac{1}{8}$	Iron	1875	125	Mississippi River and tributaries.
Helena	2	13	4							Do.
John R. Hugo	2	8	3	1	16	$3\frac{1}{2}$	Iron	1882	119	Do.
Pin Oak	2	8	$2\frac{1}{2}$	1	17	$3\frac{1}{3}$	Steel	1888	125	Missouri River and tributaries.
Albert S. Willis	2	$16\frac{1}{4}$	6	3	32	$3\frac{11}{12}$	Steel	1881	155	Mississippi River and tributaries.
New Haven										Do.

List of steamers plying on the Missouri River, in the district of New Orleans, enrolled at the port of Kansas City, during the year 1889.

Name.	Tonnage.	Date of enrollment.	Date of license.	Name and address of sole or managing owner.
			1889.	
Aggie	88.57	Mar. 11, 1887	Mar. 15	Craig and McRoberts, Sand Company, Kansas City, Mo.
Roy Lynds	64.19	June 22, 1889	June 22	Lexington Ferry and Transportation Company, Richmond, Mo.
Annie Lewis	81.14	June 27, 1889	June 27	Peter W. Cline, Kansas City, Kans.
Plow Boy	37.80	Nov. 12, 1885	July 23	William Hullett, Rocheport, Mo.
Jennie Gilchrist	74.84	July 18, 1888	July 24	Argentine Sand Company, Kansas City, Kans.
Carrie	29.82	July 27, 1888	July 27	Argentine River Improvement Company, Argentine, Kans.
Undine	72.90	Oct. 1, 1883	Aug. 20	Lexington Ferry and Transportation Company, Richmond, Mo.
Edna	80.35	Aug. 27, 1887	Aug. 21	A. B. Eades, Boonville, Mo.
Jos. L. Stephens	85.95	Aug. 31, 1887	Aug. 29	John Porter, Boonville, Mo.
Annie Cade	178.32	Sept. 20, 1883	.. do ...	William Cade, Leavenworth, Kans.
Mattie Lee	104.80	Oct. 20, 1884	Nov. 9	John Burris, Miami, Mo.
Harry Clyde	23.79	Nov. 12, 1889	Nov. 12	George W. Hawkins, New Frankfort, Mo.
Willie Cade	177.47	Sept. 17, 1887	Dec. 3	Vinton Stillings, Leavenworth, Kans.
T. F. Eckart	510.43	June 15, 1889	June 15	Kansas City Excursion Company, Kansas City, Mo.
Lillie Maud	16.25	.....	May 4	Samuel B. Cassibott, De Witt, Mo.

List of steamers plying on the Missouri River in the district of New Orleans, enrolled at the port of St. Joseph, during the year 1889.

Name.	Tonnage.	Length.	Breadth.	Depth.	When built.	Where built.	Name and address of sole or managing owners.
		Feet.	*Ft.*	*Feet.*			
John M. Abbott	97.78	92	20	3.6	1883	Madison, Ind	St. Joseph Sand Company, St. Joseph, Mo.
Belle of Brownville	102.44	110	30	3.0	1880	Grafton, Ill	J. N. Stewart, Leavenworth, Kans.
Minnona	22.04	70	18	3.0	1884	Riverside, Nebr.	John H. Lynds, White Cloud, Kans.
A. Saltzman	36.00	.....	....	.....	1889	St. Joseph, Mo	St. Joseph River Transportation and Wood Company.
J. K. Yazel	19.36	44	12	3.7	1886	Atchison, Kans	A. Saltzman, St. Joseph, Mo.

List of steamers plyiny on the Missouri River in the district of New Orleans, enrolled at the port of Omaha, Nebraska, during the year 1889.

Name.	Tonnage.	Name and address of sole or managing owner.
Andrew S. Bennett	78.08	Wm. Luther, Covington, Nebr.
Mary E. Bennett	21.71	Do.
Capitola Butt	57.03	Wm. H. Butt, Nebraska City, Nebr.
Helena	352.31	I. P. Baker, Bismarck, N. Dak.
Josie L. K	22.75	H. Drange, Yankton, S. Dak.
Jim Leighton	57.29	Shebourne Sanborn, Winona, Minn.
Little Maud	58.66	Joseph Leach, Sioux City, Iowa.
Rosebud	286.49	I. P. Baker, Bismarck, N. Dak.
Last Chance	50.47	M. R. King, Yankton, S. Dak.
W. P. Bishop	60.09	Chas. F. Potter, Omaha, Nebr.
John F. Lincoln	209.62	H. F. Jaynes, Omaha, Nebr.
Katie Pease	14.05	C. H. Peterson, Plattsmouth, Nebr.
Queen No. 2	12.00	C. E. Hull, Decatur, Nebr.

List of steamers plying on the Missouri River in the district of Minnesota, enrolled at the port of St. Vincent, during the year 1889.

Name.	Tonnage.	Dimensions.			When built.	Where built.	Date of document sailing under.	Name and address of sole or managing owner.
		Length.	Breadth.	Depth.				
		Feet.	*Ft.*	*Ft.*				
F. Y. Batchelor...	313.00	178.6	31.0	4.0	1878	Pittsburgh, Pa.....	May 31, 1888	Isaac P. Baker, Bismarck, N. Dak.
Gen'l Custer	241.34	182.0	28.0	3.8	1877	Allegheny City, Pa .	May 9, 1879	Wm. Kountz, Allegheny City, Pa.
Gen'l Terry.....	323.15	178.0	31.0	4.0	1878	Pittsburgh, Pa.....	June 1, 1888	Isaac P. Baker, Bismarck, N. Dak.
Nellie Peck.....	280.77	201.4	35.2	4.0	1871	Pittsburgh, Pa.....	Apr. 25, 1882	Helen A. Peck, Keokuk, Iowa.
Undine	76.98	115.0	30.9	4.0	....	Wellsville, Ohio.....	June 3, 1882	Wm. Braithwaitz, Bismarck, N. Dak.
Yellowstone	167 27	122.0	23.4	5.4	1876	Jeffersonville, Ind ..	June 25, 1878	A. Lawrence, Bozeman, Mont.
Ida Stockdale....	377.39	180.0	31.0	5.0	1867	Pittsburgh, Pa.....	Oct. 2, 1873	J. Haycock, Yankton, S. Dak.
Union.....	72.18	99.4	27.3	4.1	1861	Brunswick, Mo	June 12, 1879	A. Cameron, Bismarck, N. Dak.

Very respectfully, your obedient servant,

JAMES C. SANFORD,
First Lieut. of Engineers, Secretary.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

A 2.

REPORT ON BORINGS IN THE MISSOURI RIVER VALLEY.

MISSOURI RIVER COMMISSION,
St. Louis, Mo., November 1, 1889.

SIR: I have the honor to hand you herewith a report on the subject of "Borings in the Missouri River Valley." It includes all the data on file in this office, some of which have lain unfinished for years and some have lately been secured from railroad and bridge engineers and other reliable sources. The following table is an index to this report as well as a fairly complete condensation of it. The table is followed by notes under heading of the several localities.

Owing mainly to lack of funds it has not been possible to present herewith any study of these data. This would have involved a thorough search through all publications bearing on the subject. This should be and it is hoped will be done in the future. But as many of the data herein are unknown outside of this office, it was deemed advisable to submit them for publication and distribution.

Index table of borings in the Missouri River Valley.

Location.	From mouth of river.	Number of plate.	Date of making borings.	Total distance bored.	Number of borings	Deepest bore hole.	Lowest elevation reached referred to St. L. Directrix.	Character of rock.	Remarks.
	Miles.			*Feet.*		*Feet.*	*Feet.*		
St. Charles, Mo	25.1	I and II	1870–'80–'81	2,836	108	60	50.0		By Government and bridge company.
Boonville, Mo	197.0	III	1873	229½	9	55	100.5		By Boonville Bridge Company.
Glasgow, Mo	226.5	IV		132	6	38	138.5		By C. and A. Bridge Company.
Sibley, Mo	347.8	V and VI	1886–'87	1,839	30	115	106.0	Limestone	By Sibley Bridge Company.
Randolph, Mo	382.4	VII	1885–'86	193	4	104	218.2	Shale, limestone	By Chicago, Milwaukee and St. Paul R. R.
Kansas City, Mo	386.3	VIII and IX	1867–'88	877	21	90	235.0	....do	By bridge companies.
Leavenworth, Kans	416.8	X	1878–'83	632½	17	51	288.0		By Government and bridge company.
Atchison, Kans	445.8								
St. Joseph, Mo	479.5								
White Cloud, Kans	530.8	XI	1884	179½	3	79	358.0		By George S. Morison.
Rulo, Nebr	542.1	XII	1885	1,329½	13	153	291.0	Sandstone	By Rulo Bridge Company.
Arago, Nebr	552.3	XIII	1884	298	2	152	294.0	No rock	
Nebraska City, Nebr	608.5	XIV and XV	1879–'87	4,000	50	172	344.0	Limestone	By Government and bridge company.
Plattsmouth, Nebr	638.3	XVI	1881	1,398½	34	85	459.0	....do	Do.
Omaha, Nebr	667.8	XVII and XVIII	1877–'88	2,511	49	135	440.0		Do.
Blair, Nebr	699.1	XIX and XX	1883	1,557	30	70	519.0	Limestone	By bridge company.
Sioux City, Iowa	802.8	XXI	1878–'88	824½	16	105	551.0	Calcareous sandstone.	By Government and bridge company.
Chamberlain, Dak	1,068.7	XXII	1880		160	26	875.0	Chalk rock	By Chicago, Milwaukee and St. Paul R. R.
Bismarck, Dak		XXIII	1881	2,553	44	107		No rock	By Northern Pacific R. R.

NOTE.—The cost of forty-three deep borings at Nebraska City in 1879 was 95 cents per foot bored. At Sibley the cost of the deep boring was estimated by Mr. O. Chanute to have been 50 cents in sand and $2 in rock per foot bored. The cost of boring at other places is not known.

ELEVATIONS.

Elevations are in feet, and in all but one case referred to St. Louis Directrix, whose elevation is 433.97 feet above Cairo datum; 412.71 feet above 1884 determination of mean gulf-tide at Biloxi, Miss.; 416.3617 feet above mean tide at Sandy Hook by levels of the Coast Survey. (C. S. Report of 1882, App. 11.)

Elevations at Bismarck are referred to water surface of Lake Superior, whose elevation was taken by Northern Pacific Railroad Company as 602 feet above mean tide at Sandy Hook. Levels from Lake Superior to Bismarck were run by the railroad company. (Letter from A. Anderson, chief engineer.)

Slope of water surface has always been taken into account when necessary—the latest determination being used.

CONVENTIONAL SIGNS.

These are, as far as possible, uniform throughout the accompanying plates and are shown on plate II.

Defining "gumbo" as very fine sand mixed with clay and mud and dried, and silt as the same but wet, the same conventional sign has been used for both.

The size of dots indicates in a general way the coarseness of sand. Any mixing of conventional signs indicates that the elements represented by those signs are mixed.

AUTHORITIES.

These are mentioned under each head.

Messrs. James A. Seddon, R. F. Grady, and J. C. Farrar, have done much good work in the compilation of this report. The final arrangement and verification of the data given and the drawing of many of the plates are due to Prof. D. C. Humphreys, of Washington and Lee University.

Very respectfully, your obedient servant,

THEO. A. BINGHAM,
Captain of Engineers,
Secretary Missouri River Commission.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

ST. CHARLES, MISSOURI.

[Plates I and II.]

The first information we have in regard to the rock profile of the valley at this point is from the sinking of the piers of the St. Charles Bridge, which was built by C. Shaler Smith from 1868 to 1871. An account of the building of this bridge was published in the Chicago Railway Review and copied by Van Nostrand's Engineering Magazine, August, 1871. Of this article Fred. H. Smith, consulting engineer, brother of the builder of the bridge, says:

"The article * * * is copied from a Chicago railway paper and is unofficial—picked up and extended by a gaseous reporter—and contains so many errors as to discredit its many truths."

The writer of the magazine article says, "Immediately below the water, sand is encountered varying in depth from 4 to 38 feet; below (after passing heavy drift masses) there is a layer of bowlders about 21 feet thick, interspersed with sand strata of from 6 to 18 inches thickness. The bowlders are of every variety of rock found west to the summit of the Rocky Mountains." (Van Nostrand's Eng. Mag. Vol. V, pages 178–187.)

The elevation of bed rock at the piers of the bridge according to Fred. H. Smith, is after reducing to St. Louis Directrix.

Pier No. 1— 2′.12	Pier No. 5—50′.14
Pier No. 2+ 0′.91	Pier No. 6—62′.62
Pier No. 3—10′.15	Pier No. 7—65′.62
Pier No. 4—35′.19	Pier No. 8—55′.88

These elevations are nearly the same as those given on a profile and elevation of piers made by Julius Moulton, field assistant engineer, during the construction of the bridge.

The other information given on the Bridge rock profile, Plate II, is obtained from Moulton's profile.

Piers 1, 2, 3, 4, and 5 were sunk to solid rock while Piers 6, 7, and 8 were founded on piles, the bottoms of which were supposed to rest on rock. They were driven as far as they would go.

The rock profile on this bridge line sent to this office by Samuel H. Yonge, assistant engineer, in 1879, nearly coincides with the one adopted, the only material difference is at Pier No. 2, where he gives the elevation of rock about 5 feet higher than that shown on Plate II.

The next investigation of the subterranean character of the river bottom was made by L. E. Cooley, assistant engineer, in local charge of improvement at St. Charles. In his report of September 13, 1880, he says, referring specially to the depth to rock, or the lower limit of scour:

"For investigating this feature of the reach it is proposed to construct a probing apparatus of three-fourth inch gas-pipe by which not only the depth of rock may be ascertained but also a judgment formed of the nature of the intervening strata. The expense of this apparatus need not exceed $50, nor the cost of probing $1 apiece."

In subsequent reports no fnrther description of this apparatus is given excepting that the gas-pipe used was 1 inch in diameter and that it was worked by hand. It was intended to use a heavier pipe, but it could not be obtained. This apparatus worked well but was not strong enough for continued use. It was not adapted to depths of more than 50 to 60 feet. Borings were begun December 21, 1880, and continued to March 12, 1881. (See Sections A to N, Plates I and II.) During November, 1881, eighteen probings were made in the bottom between *x* and *y*, Plate I, to rock at an average distance from the bluff of 130 feet. The mean depth of rock below the surface of the bottom-land on that line was 20 feet. No levels were run over this line.

In a project for work at St. Charles, submitted February 23, 1881, by L. E. Cooley, who had formerly been assistant in charge at Nebraska City, it is said: "In this portion of the valley the strata opposed to erosion are more tenacious than in the upper river and even below low water are interstratified with argillaceous layers. At a depth of 40 to 50 feet from top of bank there appears to be a scour limit in the shape of a clay and bowlder stratum of unknown thickness, which thins out and is superimposed on the rock near the bluff. The rock profile near the bluff is of gradual slope and is often exposed at low water from 200 to 300 feet from the toe of the bluff. Although the slope of the river is very heavy, and abnormally so for this portion, the rate of erosion is not large as compared with Nebraska City, a difference probably due to difference of strata alone."

In his annual report for the improvement of the Missouri River at St. Charles, dated June 30, 1882, F. M. Harris, assistant engineer in local charge, says in regard to Section A, Plates I and II:

"The clay layers range from 1 to 3 feet in thickness, noticeable in vertical banks at low water, and are apparently continuous over large areas. While this formation, sandwiched with lighter material, affords little protection when cut through, yet it must determine in some degree the limit of scour and may account for the excessive wanderings of the chutes and draws in this reach.

"The fact that one-half of the valley on this section has been worked over by the river since 1868, would indicate that this stratification continues at the present time and is supplied from cutting banks.

"The stratum at the bottom of the borings in Sections A and B, which could not be penetrated by the apparatus at hand, seems to be identical with the bowlder-bearing stratum found in sinking the foundations for the piers of the St. Charles Bridge."

On the sheet which contained plat of Sections A and B, the following note was made by the assistant engineer in local charge:

"The character of the profiles requires further study and additional data before they can be presented with full confidence."

BOONVILLE.

[Plate III.]

Both reference map and rock profile were reduced from maps, bridge plans, and elevations, sent to this office by the bridge company, the originals having been signed by William Sooy Smith, engineer of the Boonville Bridge, and by O. B. Gunn, chief engineer of the Missouri, Kansas and Texas Railway, and of the Boonville Bridge

GLASGOW, MISSOURI.

[Plate IV.]

The only information in regard to the rock profile at this point is derived from the plans and elevation of the Glasgow Bridge on the Chicago and Alton Railroad. The map showing the location of the bridge is taken from those made from the surveys of D. W. Wellman, assistant engineer, in 1878.

The rock profile is taken from an elevation of the bridge showing a section of the river. This profile is signed by William Sooy Smith, who was chief engineer of the bridge.

SIBLEY, MISSOURI.

[Plates V and VI.]

The very interesting and complete data from this locality are due to the courtesy of Mr. O. Chanute, C. E., engineer of the Sibley Bridge.

The bridge is located on a glacial moraine which seems to have protected the bed-rock from abrasion at this point. At any rate, the first set of borings taken up the river, between Points IV and V, Plate V, showed the rock to have been worn to elevation 226 to 229 feet, and its bed to have been filled back with sand; while at the bridge site, between Points I and II, it is worn down to only 241 to 243 feet and covered over with a deposit of clay through which the river has, it is believed, never scoured.

A line of borings was made across the entire valley between points II and III, and the abrasion above-mentioned was found to be much deeper than at the bridge site. These borings were carried below the bed-rock at a number of places as shown on Plate VI, and stopped in the upper coal measures. It is believed by Mr. Chanute, that the strata run horizontally and he mistrusts the lines as drawn on Plate VI, between pier No. 5 and boring B, which seem to show a dip.

The glacial moraine at the bridge site contains bowlders of foreign rock, such as granite and porphyry, which are not found in their native beds for several hundred miles from the bridge site.

Index sheet II of the published maps of the Missouri River shows the bounding bluffs of the valley which were the margin of the ancient glacier. The point where the bridge is located seems to have formed a sort of pivot at which the glacier changed its direction and thus left the moraine of bowlders.

The method of boring is described as follows by Mr. J. F. Wallace, the resident engineer:

"Casing of gas-pipe was first driven as far as possible in the soft upper stratum; inside of which a smaller pipe was placed. In the lower end of this smaller pipe a cutting chisel or drill-point was inserted, with small openings at each side. Both these pipes were held in position by a wooden tripod. Around the small pipe was placed a handle for the workmen to operate the drill, and connected with the upper end of this small pipe was a rubber hose leading to a force pump, from which a current of water was forced through the hose, down into the small inside pipe, out through the openings at the drill-point, and up through the larger pipe, removing the sand and cuttings from below the drill-point. In soft material progress was rapid, and the outside pipe as well as the inside pipe was easily forced downward, as the water jet removed the material. When rock was reached, or a bowlder encountered the larger pipe resting upon it, prevented the sand and gravel from above clogging the bore-hole, and the water jet removed the rock cuttings from the drill-point by forcing them up through the outside pipe.

"In case a second stratum of sand or gravel was encountered, under rock or other hard material, a second casing pipe was placed inside the larger pipe, and still a smaller pipe, with a drill-point attached, used inside of it, and the work carried on as before.

"As the work progressed, and it became necessary, additional sections of pipe were added by screwing them on upon the upper end of those already in place.

"When the depth reached was such that two men could not operate the drill, block and tackle was used connecting the drill-pipe with the top of the tripod and additional labor used to raise the drill.

"The force employed upon these borings consisted of a foreman and six workmen."

The cost of boring was estimated at about 50 cents per foot in sand and $2 per foot in rock.

RANDOLPH BLUFFS.

[Plate VII.]

The information in regard to this locality was obtained in sinking the piers of the Chicago, Milwaukee and St. Paul Railway Bridge at this point. The rock profile was furnished by Messrs. Waddell & Jenkins, consulting engineers, Kansas City, Mo.

KANSAS CITY, MISSOURI.

[Plates VIII and IX.]

(See "The Kansas City Bridge, by O. Chanute, Chief Engineer, and G. Morison, Assistant Engineer." D. Van Nostrand, N. Y., 1870.)

The Kansas City Bridge was built 1867–'69, by Messrs. Chanute & Morison, and the rock profile presented on Plate IX and marked AA is substantially taken from their book.

At the bottom of Pier No. 3 the rock was found to slope downward about 3 in 40. The character of the material passed through in sinking Pier No. 4 is more fully described than anywhere else. Here mud or gumbo was first encountered which changed into coarse sand.

"Bed-rock was covered with about 3 feet of loose stones mixed with a moderate quantity of blue clay. The stones were of all sizes from small pebbles to bowlders containing 2 or 3 cubic feet. The larger ones were mostly of limestone, and showed few or no signs of wear; the smaller pebbles were well-rounded and of divers geological characters, presenting a strange collection of the different formations found on the eastern slope of the Rocky Mountains. Sandstone, granite, moss-agates, and many other minerals were mixed in wild confusion, while bits of water-charred wood, reduced almost to pure coal, and several varieties of teeth were found among them."

The larger stones showed by their roughness that they have seldom, if ever, been disturbed by water.

A hole was drilled for 5 feet into the rock and no sign of flaw or weakness was discovered.

In sinking Pier No 5, the material first excavated was a fine silt, but as the depth increased it changed to coarse sand in which were found occasional masses of clay and a few stones. In one instance the caisson reached what appeared to be a thin continuous layer of clay. In this case the caisson was not sunk to bed-rock but borings found rock at the elevation of 255.37 feet which was 31.5 feet below the bottom of the caisson. Nearly 100 piles were sunk to solid rock.

At Pier No. 6 the bottom of the masonry was at the elevation 301.57 feet below which level 90 piles were driven to an average depth of 30 feet through sand, it was supposed.

At Pier No. 7 the bottom of the masonry was at the elevation 307.97 feet, and 73 piles were driven through what was thought to be sand to an average depth of 27 feet.

In a letter from J, W. Nier, who was, at the time the letter was written, United States Assistant Engineer in charge at Kansas City, he says:

"The only boring that we have any knowledge of (bridge borings excepted) was at Plankington & Armour's packing-house, where a pipe was sunk 87 feet without finding anything but quicksand. No notes were kept, that I can find, of the material passed through, since they were trying to reach gravel for water. This boring was in the Kaw bottom but a short distance from the Kansas City revetment."

Surveys and investigations have been made, and designs drawn by Waddell & Jenkins, consulting engineers for the C., K. C. & T. R. R. bridge, which is to be 2,700 feet down-stream from the Kansas City Hannibal & St. Joseph bridge.

From the section given in these designs, rock profile B-B, plate IX is taken. In their letter dated July 29, 1889, they say:

"We find in our recent borings no evidence of a solid stratum of limestone rock. Our borings show, however, a compact mass of calcareous matter which resembles limestone rock; but we can not call it a solid stratum of rock. The stratum of shale seems to extend nearly horizontally across the river."

LEAVENWORTH, KANSAS

[Plate X.]

Borings 1, 2, 3 and 4, were made by D. W. Church, United States Assistant Engineer, and the information in regard to them is contained in his Annual Report dated July 1, 1879.

The instrument used was similar to that used by Assistant Max Bœhmer, at Omaha, Nebr., and called a "jigger" The material passed through is shown on the drawing.

Boring No. 3 was made at the mouth of Bee Creek "to the depth of 45 feet, but owing to failure in the instrument only two specimens were obtained; the first taken at 10 feet below the surface, the second at 45 feet, a compact clay being found in each case."

It was noticed that in borings Nos. 1 and 2 the coarser material found near the surface was underlaid with fine sand or quicksand, while No 3, it was thought, was through clay for the whole distance. The nature of this clay is not known, nor is it evident where it came from.

Boring No 4 was intended to reach solid rock, but 57 feet was the greatest depth reached. The specimens taken out were very uniform and all fine sand.

The locations of borings 1, 2, 3 and 4 are uncertain both as to horizontal position and elevation.

In January, 1883, the Missouri Valley Bridge and Iron Works Company made borings at Leavenworth in prospecting for a bridge. All the information obtained from them is on a blue print of their map, showing location and profiles. From these borings Sections A-A and B-B are taken.

ATCHISON, KANSAS.

[No plate.]

In his report dated September 11, 1878, Chester B. Davis, United States Assistant Engineer, states that the formation near the passenger depot consists of 12 feet loam and sandy soil, 35 feet clay, 5 feet quicksand, and 5 feet gravel and bowlders.

In his report dated December 4, 1878, he states that "borings have been made at the lake and a depth of 50½ feet reached. The last stratum was a fine gravel mixed with sand. All the material between this and the surface was pure gumbo, except at a depth of 45 feet a thin layer of sand was found."

As far as is known these borings were not located.

ST. JOSEPH, MISSOURI.

[No plate.]

Frank Hotchkiss, United States Assistant Engineer, states that borings were made, and that "the results of the borings even with the best appliances we can obtain are rather unsatisfactory; but one fact seems to be definitely settled, viz., that after passing the upper layer of soil there is a solid bed of sand reaching to a depth of at least 48 feet."

In a letter dated October 6, 1879, D. W. Church, United States Assistant Engineer, gives information which, he says, was gotten from Dr. Gunn, superintendent of the St. Joseph bridge, in regard to the strata composing the left bank of the river at the bridge. According to this authority (the elevations being referred to St. Louis Directrix), we have:

[Water surface, September 19, 1879, elevation 383.8 feet.]

	Feet.
13.8 feet soil from	383.8 to 379.0
12 feet quicksand from	370.0 to 358.0
9.8 feet sand from	358.0 to 338.2
9.2 feet gravel from	348.2 to 339.0
9 feet bowlders from	339.0 to 330.0
Rock from	330.0

It is thought that some information in regard to borings in this locality was burned in a fire in the St. Joseph office of the United States Improvement of the Missouri River.

WHITE CLOUD, NEBRASKA.

[Plate XI.]

These borings were made in 1884 at White Cloud by George S. Morrison, Consulting Engineer; and a plot was sent to this office from which Plate XI was prepared.

Borings 2 and 3 seem to show that the stratification is horizontal, and it is supposed that the water has at some time cut through the thin layers of rock, which were penetrated in boring 1.

There were no notes sent in on this point, and the drawing of the rock profile, between borings 1 and 2, is not presented with any confidence.

The elevation of the zero plane, used by Mr. George S. Morison, was found by comparing gauge readings to be about 412.4 feet below St. Louis Directrix.

RULO, NEBRASKA.

[Plate XII.]

The information in regard to borings at this point is derived from profiles and maps sent to this office by George S. Morison, chief engineer, and B. L. Crosby, resident engineer of the Rulo Bridge, Burlington, and Missouri Railroad in Nebraska.

ARAGO, NEBRASKA.

[Plate XIII.]

The only information we have at this point is two borings, one on each bank of the river, which were made under the direction of B. L. Crosby, C. E. The levels were not taken, either of the surface of the water at the time the borings were made or of any Missouri River Commission bench-mark. Mr. Crosby says he can give information by which a man on the ground could determine the levels within a foot or two.

The levels as shown on Plate XIII can not be relied on, but are probably not more than 5 feet out of the way.

NEBRASKA CITY, NEBRASKA.

[Plates XIV and XV.]

The first borings were made in 1878. None were deeper than 50 feet. They were made with a crude "probing" apparatus which was afterwards developed into a very satisfactory plant, but need not be described here. Tracings of it and of the plotted borings will be found in the office files. These 1878 borings, twelve in number, were located along the same line as shown for the 1879 borings (Plate XIV) from 2 to 25, and then straight across to 26 and 27. Hence the results are practically the same as shown later in 1879.

In 1879 forty-three well-distributed borings were made during the summer and autumn by a party under the charge of Mr. E. H. Wilson. The total number of feet bored was 3,737.85, at a total cost of $3,560.42, or 95¼ cents per foot.

The apparatus used is fully described in Annual Report Mississippi River Commission for 1881, page 171, Appendix J, Plate 13.

Detailed results are shown on Plate XV.

The section on Bridge line, shown on Plate XIV, is taken from a section sent in by Mr. B. L. Crosby, formerly assistant engineer of the Nebraska City bridge.

The following discussion is from Mr. E. H. Wilson's report of December 1, 1879:

"Generally, though with many special differences, these sections show that beneath a silt or clay bed of from 2 to 12 feet a bed of sand exists to a depth of from 30 to 40 feet, and thence to the limestone or shale bed-rock gravel is found.

"As we near the bed-rock the gravel increases in size, and limestone bowlders, of diameters greater than 3 inches, abound.

"The edges of these bowlders are decidedly waterworn; but their generally angular appearance as well as their size, would indicate that they are not far distant from their original resting place, and further, that they are rarely disturbed by the currents of the modern river.

"Specially these sections show striking difference; thin layers or pockets of sand and clay indicating the varying intensity of the forces that have built up these alluvial beds.

"A net work of bench-lines covering the bottom in this vicinity records the fact that the modern river has repeatedly worked over the upper deposits.

"The river does not often cut to a greater depth than 30 or 40 feet, though when checked in its tendency to spread, by natural or artificial means, a greater depth is attained, making possible the deposit of finer material in the place of the lower gravel.

"An example was afforded by the resistance to lateral erosion of the revetment just above Eastport, Iowa, along which the current of the Missouri passed during the high water season of 1879 in a comparatively narrow channel, where soundings of 70 feet were obtained.

"Here, undoubtedly, the slackening current deposited sand, and, altering its course, built a bar at the head of this deep channel, leaving a basin, still deeper, whose bottom even now, in all probability, bears a thin clay deposit.

"Should only the gentle currents of succeeding floods enter here, a characteristic mud or clay pocket would speedily be built, which the river at some future time could only undermine by scouring below its normal depth.

"One of these clay beds, whose limits have been approximately determined by shallow borings about Boring No. 20, was known to steam-boat men as "Mud Point," and its pocket-like character is clearly shown by the result of the borings. (Plate XIV.)

"Where the river is cutting into a sharp bend, as 2 miles above Eastport, the apex of the opposite bar, slowly building in comparatively swift water, discloses the heavier deposits near the surface.

"Where the channel changes direction suddenly, the depths left with sluggish currents may be filled with sands varying in color and degree of coarseness, not only vertically but horizontally, gradually marked differences, as due to gradual changes in the intensity of the currents; strongly marked, as due to the sudden daily or yearly variations of the power of the transporting force.

"These gradual vestical changes, sometimes in thin sometimes in thick layers, are seen clearly while the boring is in progress; though they can not clearly be shown, save in the thicker layers, either by specimens or drawings.

"These layers are particularly distinguishable as we near the surface deposits the material of the layer, recording the growth of, perhaps the year, gradually growing coarser as we descend, shaded from fine mud, or clay, to fine, to coarse sand.

"Sometimes, though rarely, the direction of this gradation is reversed.

"Besides the unhomogeneous character given adjacent deposits by the varying currents, further local peculiarities may be imparted by the sorting action along edges of bar by the waves.

"This force is not less active, though not so apparent here as on the lower Mississippi, where along the margin of bars the surface gravels are left in lines and pockets, the finer material disappearing with the retreating wave.

"The wind, under different conditions, excavating or building up about drift logs, in the first case, affords a basin for the finer silt or clay of the succeeding flood; in the latter breaks the uniformity of the bar surface by a sand mound.

"These borings show, in their special differences, the varying action of the currents of a shifting stream even in the lower gravel beds.

"An interesting result of these borings is the disclosure of a pre-glacial channel, found 3 miles north of Eastport, running at right angles to the direction of the Missouri River Valley.

"The northern bank, located between Borings No. 26 and 27, is fixed here within a limit of 100 feet.

"What the width of the fissure is was not determined, though it is less than 2,500 feet.

"The borings indicate a depth of 165 to 175 feet beneath the present surface, 60 to 75 feet deeper than the rock-worn bed of the old Missouri.

"The channel was traced eastward in Borings Nos. 23, 21, 19, 20, and 26, and its continuity further proven by the last boring on the line of the valley cross-section (No. 38, 4 miles from No. 26) and its general direction shown to be S. 80° E.

"The principal bed in this rock-bound fissure below the general level of the north and south valley of the Missouri, is a very hard, tenacious, drab-colored clay mixed with angular fragments of stone, generally of lime, though, in one observed instance (Boring No. 23), of red quartzite, the prevailing bowlder material of the northern glaciers.

"This is undoubtedly the bowlder clay of the glacial era.

"With these beds above, below, and between them are beds of water-worn sand and gravel with very hard clay balls of the bowlder-clay material.

"A shallow bed of this same clay lies upon bed rock, 3½ miles north of the old river fissure, where, as is shown by borings Nos. 9 and 13 on either side, a depression exists in bed-rock of the Missouri.

"The position of the sand and gravel beds in reference to the bowlder clay deposit would seem to indicate that the currents of the old river were active during the glacial era: sorting and depositing its material after the fashion of modern streams.

"The very hard clay balls should further indicate that the damming action of the glacial deposits was not unresisted.

"It is believed that this channel could be traced by boring on either side of the Missouri Valley, which, had time afforded, was contemplated.

"A line following the general direction indicated by these borings as the direction of our pre-glacial stream would enter the bluffs at points where not only is no rock visible, but where the glacial loess, or 'bluff' deposits, are particularly noticeable.

The only considerable stream having the general direction that the old channel shows is the Platte, and in this connection the abrupt turn eastward of this stream from a point 20 miles above its mouth is suggestive.

"A curious feature of the surface topography here is the sand-mounds. They are elevations, with but scanty vegetation, of varying size, sometimes with quite steep slopes, and a height of 10 feet or more, they present the appearance of an artificial construction.

"These mounds are seen in great numbers in the bend between borings Nos. 11 and 23, on old ground.

"Boring No. 27 shows their character; fine sand resting on the ordinary silt or clay deposits.

"Their origin is undoubtedly due to the wind.

"Assistant L. E. Cooley points out one, near boring No. 11, that the wind has reared within the past few years, which, still growing, has already hidden the trunk of comparatively old and still living trees.

"These mounds bear witness to the important part the wind plays as a building power.

"Possibly the intimate mixture of coarse sand and mud frequently observed can be accounted for through the agency of the wind.

"It has been thought proper to record here the geological characteristics of the vicinity.

"A general description of the prevailing formation may be found in Swallow's Missouri report, or White's report on the geology of Iowa.

"The older rocks exposed in the vicinity of Nebraska City are exclusively of the upper carboniferous period.

"One mile south of Nebraska City in the Nebraska bluffs, exposed in a railroad cut, a 3-inch vein of impure coal with clayey partings dips southward and is lost to view in the débris of the slope. This trace is all that appears of the coal beds in the vicinity.

"Borings of several hundred feet depth have failed to reach coal.

"It is to be regretted that notes of the material passed through could not be obtained.

"One-quarter of one mile below Bolware Hollow (see tracing) the ledge of impure clayey limestone from which Assistant Cooley obtained his rock supply in the spring of 1879 is located.

"The ledge, upwards of 3 feet thick, is not represented in cross-section of bluff shown on map. It is either missing entirely or represented by a much thinner bed.

"At Bolware Hollow (below Nebraska City) resting upon shales (variegated in color) and impure limestone, about 22 feet above low-water mark, is an 11-inch bed of blue limestone (No. 17 of cross-section) which is quarried for local building purposes.

"This, among the many layers of limestone exposed here, is the only stone that successfully resists the action of frost.

"It has been quarried in South Table Creek, where it is somewhat lower than where exposed in bluffs.

"With varying thickness the layer is found at Walnut Creek and in Assistant Cooley's quarries at Wyoming, at about the same elevation above low water.

"Proceeding northward from Nebraska City, along the Nebraska Bluffs, and leaving a low bluff section showing only loess, the bluffs are wooded and not precipitous.

"At Walnut Creek quarrymen have uncovered beds of rock, but from this point to Wyoming none is exposed.

"One-half mile below Wyoming the bluffs show a nearly vertical section of the drift deposits about 80 feet in height.

"The deposit upon which the bowlders and sand rest presents nearly the same appearance that do the loess bluffs (differing in being a shade lighter in color) but an examination shows it to be very finely powdered silica without lime, undoubtedly a glacial deposit.

"At Wyoming the bluffs are rocky.

"A thick bed of red or purple shale exists from low water, which abounds in limey concretions, generally flattened, with micaceous exteriors.

"Stripping in the quarries along the bluff at this point shows various deposits resting upon the carboniferous beds; one of drift origin is a bed of dark brown clay with a vertically jointed structure. Generally the bluff formation (loess) is exposed.

"The upper shales recorded in cross-section at Nebraska City are present here, but in very thin and waving bands, as shown in the bluff; the sandstones are missing.

"The hills bordering Weeping Water Valley while well defined are not bluff-like.

"The prevailing loess is sometimes replaced by traces of drift; but in this large valley, as in smaller ones, the boundaries of the original valley are contracted, first by drift, and then by the loess, which is exposed as the surface deposit throughout this region.

"As we approach the Jones Point, the drift has been exposed at various places by searchers for building sand, which, of excellent quality, is found in great abundance wherever the drift beds can be reached.

"Along the margin of this valley springs abound.

"It is not apparent what has arrested the downward progress of the waters of these springs, though probably the clays of the drift are responsible.

"At Jones Point a coal seam outcrops in bluffs and is exposed at extreme low water and has been worked.

"The bed, as shown in the shaft, is about 12 inches thick.

"In the few feet of the shaft untimbered, a second layer of impure, shaly coal is seen beneath a bed of fire-clay.

"But little information could be obtained concerning the mine.

"The coal exists as a pocket, upon the extreme northern limit of which the shaft has been sunk.

"The bluffs, which to the south of the shaft show only loess and drift, to the north disclose a succession of thick limestone ledges rising gradually until, at a distance of one-quarter mile, the drift and loess disappear and limestone is alone seen.

"These limestone beds abound in fossils; principally the characteristic brachiopods, specimens of four or five species of which are preserved by Assistant Cooley.

"One species of Lamellibranch (the *Allorisma subcuneata*) and very perfect specimens of the *Petraia cornicalum* ('horn coral') were found, with many crinoid stems.

"A thick, cherty limestone layer, appearing above the water surface one-half mile north of the coal shaft and marking the anticlinal axis of the fold, is made up almost entirely of the microscopic rhizopods, fusilinæ.

"Iron nodules abound in many of the lime layers; also calcite crystals.

"Enormous quantities of rock could be obtained here without the cost of stripping.

"These same thick beds of limestone appear in the opposite bluffs.

"Leaving this fold, however, in the Iowa bluffs (which is seen 4 miles north of the point where line of cross-section intersects the bluffs), the drift beds and bluff formation alone appear.

"The drift deposits are of great depth and composed of clays, fine and coarse sand, and bowlders; sometimes granitic, generally of red quartzite.

"Some of these bowlders, seen on the highland road between Nebraska City and Wyoming, are upwards of 4 feet in diameter; several are reported in the vicinity of much greater size.

"One bowlder 15 inches in diameter is a pudding-stone of cemented quartz pebbles; mention is made of it from the fact that no similar drift material is mentioned, as found here, by the geologists.

"The bluff formation, as it has been termed, or loess, extends in this locality over a wide area.

"White records its disappearance in Iowa 60 miles to the east; gradually thinning out on and replaced by the underlying drift, which, very deep, forms the watershed of the Missouri and Mississippi drainage system.

"Assistant Cooley noticed the loess in a railroad cut near Lincoln, Nebr., lying 10 feet thick upon the drift.

"Though popularly called clay it has but little alumina; rarely more than 12 per cent., generally less than 5 per cent.

"It abounds in limey concretions, frequently of a chalk color and texture, and all its observed fossils have been of fresh-water origin.

"A peculiarity of the formation is that it will retain water neither upon its surface or within its depths. Penetrating the loess, however, an abundant water supply is found in the gravels of the drift.

Notes of bluff section (taken at several points) near Bolware Hollow, Nebraska City, Nebraska.

Number of specimen.	Description.	Thickness of layer.	Elevation above datum plane whose elevation above St. Louis directrix = 431.438 feet.
		Feet.	*Ft. in.*
1	Purple, clayey shale	9.2	62 2
2	Light yellow and green shale	3.7	71 4
3	Soft, yellow limestone	1.0	75 1
4	Brownish yellow shale	0.1	76 1
5	Gray limestone concretions	0.5	76 2
6	Brownish yellow shale	0.5	76 7
7	Gray limestone	1.2	77 2
8	Yellowish brown shale	0.1	78 4
9	Gray limestone	0.6	78 5
10	Yellowish brown shale	0.1	79 1

Notes of bluff section (taken at several points) near Bolware Hollow, Nebraska City, Nebraska—Continued.

Number of specimen.	Description.	Thickness of layer.	Elevation above datum plane whose elevation above St. Louis directrix =431.438 feet.
		Feet.	*Ft. in.*
11	Gray limestone	0.6	79 2
12	Green (light) shale	0.8	79 8
13	Gray limestone	0.2	80 6
14	Dark blue shale	2.2	80 8
15	Brownish gray shale	0.9	83 0
16	Bluish gray shale	2.6	83 9
17	Blue limestone	0.9	86 5
18	Blue shale	0.5	87 4
19	Grayish blue limestone	0.3	87 9
20	Dark blue shale	0.8	88 2
21	Grayish blue limestone	0.8	89 0
22	Grayish blue shale	3.5	89 8
	Railroad grade	0.0	90 8
23	Purple shale, limey	1.5	93 3
24	Limestone, light green tinge	1.5	94 8
25	Purple shale	1.3	96 3
26	Light green clayey limestone	1.2	97 6
27	Dark shale, 1 to 2 inch layers	5.0	98 8
28	Limey, brittle shale	3.5	103 8
29	Light drab-colored limestone; fossils not perfect; calcite crystals	0.8	107 3
30	Soft, yellow clay shale thinly laminated	16.2	108 1
31	Yellow sandstone, quite hard	3.0	124 3
32	Soft, yellow sandstone, with clayey partings	4.0	127 3
33	Thinly laminated, micaceous, sandy shale, yellowish red	4 5	131 3
34	Same as 33, but quite hard	5.0	135 8
35	Clay and shale wash	2.0	140 8
36	Loess or "bluff formation," varying in depth between 50 and 125 feet	0.0	142 8

"Specimens from 30 to 35, inclusive, contain no lime; all the others are highly calcareous.

"Most of the dark-colored shales are greasy to the touch, from which characteristic—merely argillaceous—they have been popularly miscalled 'soap-stones.'

"Many of the thinner clay layers appear at other points as limestone and conversely, as the amount of lime varies; being by no means persistent in either type.

"While, in a wide sense, the carboniferous rocks in the vicinity are in horizontal layers, locally the variation from this position is quite noticeable.

"The only trace of drift, seen near point where cross-section was taken, is a shallow bed of gravel (red quartzite prevailing) resting upon the rocks as eroded on the north side of Bolware Hollow.

"The dimensions of this hollow are contracted greatly by the subsequently deposited loess."

In the autumn of 1880 thirty-two borings were made in Copeland's Bend, many of them in water from 6 to 10 feet deep.

These borings aggregated about 1,920 feet; their total cost was $296.59, or about 15 cents per foot.

The apparatus used was a decked boat, 8 by 40 feet, with a 3-inch well-hole over which stood a tripod, 16 feet high, with an intermediate staging, and one on top large enough to accommodate two men. Gas pipe of 1 inch diameter, in lengths of 8 feet, was used; and to the upper length was secured a solid iron head to receive pounding from a wooden maul. Short experience taught that the open pipe could be sunk with greater rapidity than a steel point, and in most cases a sample of the last stratum entered could be brought up. In each case the boring was made to a depth such that the friction of the material through which the pipe passed produced vibrations sufficient to neutralize the effect of the maul. A depth of 55 or 65 feet was usually reached below the surface of the bottom land in the vicinity.

The results of the borings showed that rock or heavy strata are not at all likely to be reached in this bend by scour resulting from regularization works.

PLATTSMOUTH, NEBRASKA.

[Plate XVI.]

All the information in this office in regard to borings between the Missouri and Platte Rivers, 1, 2, 3, 4, 6, and 7, is given on Plate XVII. In his annual report dated June 30, 1882, Assistant Engineer W. H. McKnew says:

Samples were taken at different depths showing the character of the various strata below the subsoil to range between very fine sand and coarse gravel. The apparatus used would not admit of greater penetration than 82 feet.

There has been no direct connection between the bridge and Government levels, consequently the elevations referred to St. Louis Directrix may be in error by as much as 1 foot. The connection was made in the following way: The elevation of the lowest part of the superstructure, as given in the Annual Report for 1889, is 592.6 feet; the distance of this part below the bottom of the rails, as taken from the published details of the bridge, is 4.34 feet, hence—

	Feet.
Elevation of bottom of rail, Government levels	596.94
Elevation of bottom rail, bridge levels	566.00
Elevation of bridge (and railroad) datum	30.94

This datum is an arbitrary one and was taken as 100 feet below low-water mark at Burlington, Iowa.

Section C was obtained from two tracings which came into the St. Louis office when work was discontinued at Plattsmouth. These tracings are duplicates of two sent in by Assistant Chas. S. Pease, with his letter dated Council Bluffs, Iowa, May 27, 1881.

From George S. Morison's report on the Plattsmouth bridge the following information in regard to the section at this point is obtained:

Pier No. 1.—"It was generally believed that the rock which underlies the bluff extended beyond the low-water mark at a depth but 2 feet below the water; and the borings, made by Mr. Tennent in the spring of 1879, had found the rock at the pier site at about the assumed low-water level; he had drilled into it 3½ feet and reported it as solid rock evidently in position."

When the excavation was made for the pier, it was found that the rock reached by the boring was one of the bowlders which were found buried in a mass of hard blue shale or soap-stone. For any other location than the bank of a great river this mass of bowlders and soap-stone would have made a sufficient foundation. The pier was sunk to an average elevation of 497.3 feet (above St. Louis Directrix).

The bowlders mentioned above were soon passed; the excavation for Pier No. 1 was continued through solid shale or soap-stone, which was in horizontal strata and had evidently never been disturbed. "The stage of the water in the river was 498.7 feet (529.7 feet St. Louis Directrix), and the material was so tight that the water was kept out of the pit, which was more than 32 feet below the surface of the river, by a single 4-inch Andrews pump driven by a ten horse-power engine and running less than one-third of the time.

"The rock was carefully cleaned off and found to have a dip of about 1½ inches in the width of the foundation (21 feet) towards the bluff, and about 5 inches in the length of the foundation (49 feet) down-stream."

Two holes were drilled to ascertain the character of the rock with the following results:

	North end.	South end.
	Feet.	*Feet.*
Hard rock	0.66	0.66
Softer rock	1.08	.....
Soft rock	.....	1.33
Hard rock	.58	1.66
Soft black shale	.83	.....
Soft rock or shale	.....	1.83
Harder rock	1.41	.....
Hard rock	.....	1.33
Soft rock	2.00	.....
	6.56	6.81

Pier No. 2.—Bed rock was reached at the elevation 495.2 feet. It was generally level with a little slate on top but wholly free from bowlders or other loose rock. A hole was

drilled near the north end for 5 feet; for 1½ to 2 feet the rock was hard, then came a softer layer, then hard rock again.

Pier No. 3.—The material was at first fine sand, which gradually grew coarser as the depth increased. Bowlders were struck at an elevation of 476.25 feet and bed-rock at 475.3 feet.

Pier No. 4.—This pier was founded on bed-rock at an elevation of 473.9 feet, which was overlaid by a thin layer of soap-stone.

Pier No. 5 was founded on 78 piles.

OMAHA, NEBRASKA.

[Plates XVII and XVIII.]

(Note books of 1877 and 1878, Surveys, especially Levels I and Nos. 2 and 4.)

Borings 1 to 27 in front of Omaha were made in 1877 and 1878 by Assistant Engineer Max Boehmer. A cross-section of the valley was begun by him, but he left the work without finishing it. Section C shows how much was accomplished, and, with a change in the vertical scale, is taken from a map which was prepared under Boehmer's direction. Assistant Boehmer did not locate Section C on any of his maps, and there may be some inaccuracy in its location, excepting that the location of the point of bend is known to be accurate. There seems to be but little doubt that the datum plane used for Boehmer's levels was the zero of the Union Pacific Bridge gauge (=545.92 feet above St. Louis Directrix), which was low water 1863 and 19 feet below high water of 1867. It is probable from examining adjacent borings that boring 19 shows bed rock too low and that 20 showed it too high. If this be the case the rock slopes from the bluff towards the river.

Borings were made near the foot of Iowa Lake in September, 1880. Of these, 1 and 2 showed hard gumbo, while 3 to 12, inclusive, showed soft substrata to a depth of 30 feet below high water (supposed to be high water of 1867 at Union Pacific Bridge =564.92 feet above St. Louis Directrix).

Accompanying his letter dated May 27, 1881, Assistant Engineer Chas. S. Pease sent in a tracing taken from the Union Pacific Railway Company's drawing of the "Substructure and foundation of the Union Pacific Railway Bridge," from which the full lines and location of hard pan, in section A, are taken. The broken lines are from a blue print, which was sent in by George S. Morison, the chief engineer of the new Union Pacific Bridge. The discrepancy in the elevation of bed rock is not accounted for, unless it be that the drawing sent in by Mr. Morison was made before the sinking of the piers for the new bridge, and consequently the elevation of rock was unknown.

Some difficulty was had in locating the high water of 1867 as a reference point; but study of the data points to the strong probability that it was 19 feet on the bridge gauge (=564.92 above St. Louis Directrix), and upon this assumption the vertical scale of elevation is put on section A.

Section B is taken from a map and is along the line on which it was proposed to build the Omaha and Council Bluffs Bridge. The company decided to build on the location shown on the map, but we have no trustworthy section showing the strata as they actually found it in sinking the piers. In regard to this bridge see report of Lieut. Theo. A. Bingham, on the Omaha and Council Bluffs Bridge, dated January 26, 1888.

BLAIR, NEBRASKA.

[Plates XIX and XX.]

All the information possessed by this office is obtained from the printed report of Mr. George S. Morison, chief engineer of the Blair Crossing Bridge, to Mr. Marvin Hughitt, president of the Missouri Valley and Blair Railway and Bridge Company.

Owing to there being no bluff contact at Blair, borings were made at Decatur, 50 miles up the river; and the report states that "the result of borings at Decatur showed an exceptionally bad bottom and made it inexpedient to consider the project of building a bridge there."

Substantially all the information given in the report in regard to the borings at the Blair Crossing is given on Plates XX and XXI. The bed rock is probably limestone.

SIOUX CITY, IOWA.

[Plate XXI.]

Three borings were made by the Sioux City and Pacific Railroad Company, which are shown on Plate XXII, marked A 1, A 2, A 3. The next borings that we have any

record of were made in 1878 by Assistant Samuel H. Yonge, four of which are shown on the Iowa shore-line, approximately located and numbered 5, 6, 7, 8. The material passed through is shown on the elevation of these borings. No levels seem to have been taken from any fixed datum.

Of the other borings made at this time, Mr. Yonge says in his report, dated August 16, 1878:

"The borings made indicate that the upper layer of the river bed, immediately below the mouth of Perry Creek, is creek mud so soft that the sounding lead will sink through it to the next layer below. The thickness of this mud layer varies from 1 to 8 feet. This layer is succeeded by a layer of finely comminuted sand from 2 to 4 feet thick, and this is underlaid by a compact layer of mixed particles of clay and coarse sand which was very hard to bore through. The last layer referred to appears to lie about 19 or 20 feet below the top of the river bank, and may be safely considered as the limit of scour. The character and positions of the layers on the Nebraska shore, opposite and above town, appear to be very similar to those on the Iowa shore."

Four probings were made in March, 1881, and are numbered 1, 2, 3, 4, on Plate XXII. The instrument used is shown in the corner of the plate; of it Assistant Yonge says (April 6, 1881): "In making these probings a steel-pointed probe was used." In connection with this, three-fourths-inch gas-pipe was used in 10-foot sections, but, finding it was not strong enough to resist bending, three-fourths-inch rods connected with common gas-pipe were substituted.

These couplings were found to be too weak to withstand the force it was sometimes necessary to apply in forcing the rod through compact layers of sand, and one of the steel points was lost by the breaking of the coupling. "In the event of further probings it will be necessary to use couplings somewhat similar to that shown" in the accompanying drawing.

Section A is taken from a drawing sent in by Assistant Yonge with his report dated April 6, 1881. He says in regard to it that "the bed-rock seems to be of the same character as that which crops out on the bank of the river, a calcareous sandstone of very loose texture, which disintegrates rapidly when exposed to the weather."

Section B is taken from tables sent to this office by J. W. Fiege, assistant engineer for the Sioux City Bridge Company, with his letter dated March 7, 1889.

CHAMBERLAIN, DAKOTA.

[Plate XXII.]

Probings were made near Chamberlain and Brûlé City, Dak., in January, 1880, by the Chicago, Milwaukee and St. Paul Railway, to ascertain the best site for a bridge. The river was frozen at the time, and the probings were made through the ice, the distance being measured to the bottom of the river and to "hard bottom," which was supposed to be rock.

In his letter dated March 7, 1889, Mr. D. J. Whittemore, chief engineer of the railway company, gives the elevation of the ice at the proposed bridge site as 736 feet above Lake Michigan. Assuming that Lake Michigan is 581.28 feet above sea level at Sandy Hook and that the elevation of St. Louis Directrix above sea level at Sandy Hook is 416.36 feet, we have as the elevation of the ice at the bridge site above St. Louis Directrix, 900.92 feet.

The elevation of the water surface at the same point on September 30, 1882 (Wellman's survey), was 910.6 feet. We have no gauge-reading to compare the stages of water at the two dates, but by comparing the maps, the stage must have been about the same, that is to say, the elevation of the ice in January, 1880, must have been about the same as the water surface September 30, 1882, and the elevations on Plate XXII are based on this assumption.

As the river usually falls slightly from September 30 to January, these elevations may be from 1 to 1½ feet too high.

In this letter of March 6, 1889, Mr. Whittemore says that further examinations at the proposed bridge site have shown that hard rock, suitable for foundations, is found 10 feet below the "hard bottom" shown on Plate XXII, section F.

All further information in regard to borings at this point is given on Plate XXII.

BISMARCK, NORTH DAKOTA.

[Plate XXIII.]

All the information we have at this point is the printed report of Mr. George S. Morison, engineer and superintendent of the Bismarck bridge, to A. Anderson, engineer in chief of the Northern Pacific Railroad.

One peculiarity of this section is the "entire absence of any proper rock in the formation of this country." For foundations this is a matter of small consequence, as the underlying formation is a very hard clay of indefinite thickness, which seems entirely proof against the action of water and is capable of sustaining great weights. "At the time the substructure specifications were drawn up it was supposed that the hard material which has been found by the borings was a soft species of rock. Further borings proved that this was not the case. It was a hard stratified clay which, in the matter of strength and behavior, under strain, resembled rock more than earth, being almost impervious to water. It seemed to be almost entirely indestructible under water; when exposed to air, however, this very hard clay rapidly slaked and after a few days could be pecked to pieces, and when once reduced to a powder it could be mixed in a soft puddle like any other clay. This clay extends indefinitely over this whole portion of Dakota; occasionally thin layers of sandstone not much harder than the clay and veins of lignite are found in it, but neither the sandstone nor the lignite is sufficiently extensive to make an important feature in the great mass of clay. Near the site of Pier I a hole was sunk into this clay 100 feet deep which stood without tubing.

"At a point in the city of Bismarck about a mile and a half from the east end of the bridge an attempt was made to sink an artesian well, and a hole was drilled 1,300 feet without finding water; the elevation of the surface at this place was 1,760; occasionally very thin streaks of what appeared like a soft rock were struck in drilling this well, but practically the entire hole was run down through clay, the bottom of which had not been reached when the boring was abandoned."

Pier I.—"Pier I was located on the east side of the river close to the edge of the river bank, the ground there being at an elevation of about 1,640. An open pit was excavated and carried down to the elevation 1,600, or more than 20 feet lower than the surface of the river alongside, without the use of a pump. The surface earth was soft, but very soon the hard clay was reached; this clay had an irregular surface, and the stratifications followed the contours of the surface; a few feet below the surface several large sandstone bowlders were found embedded in the clay; these bowlders had no horizontal strata, but seemed to be built up by a series of layers conforming in shape to the outer form of the bowlders. The material seemed entirely impervious to water; it was never necessary to pump, and the only water which came in was a very strong alkaline spring water, which evidently did not come from the river, and which was kept out without difficulty without bailing."

Pier II.—"No obstructions of any consequence were encountered in the descent of the caisson, the material passed through being a very fine sand of quite uniform character. It continued fine to within a few inches of the surface of the clay, none of the coarse sand which has generally been found below the fine sand in the foundations of bridges on the lower Missouri being encountered.

"The surface of the clay was quite uneven, the extreme difference of elevation within the area of the caisson being 11 feet; about one-third of the surface was covered with bowlders which were generally of sandstone, and the space between them was filled with a fine gravel. The fact that the irregularities of the surface were repeated in the strata of clay showed that these irregularities were in the original formation, and not due to any wash of the river. The clay was all exceedingly hard; but a black stratum which was found over the whole area of the pier, about 3 feet below the surface, was especially so. It was difficult to drive a pick more than an inch into this clay."

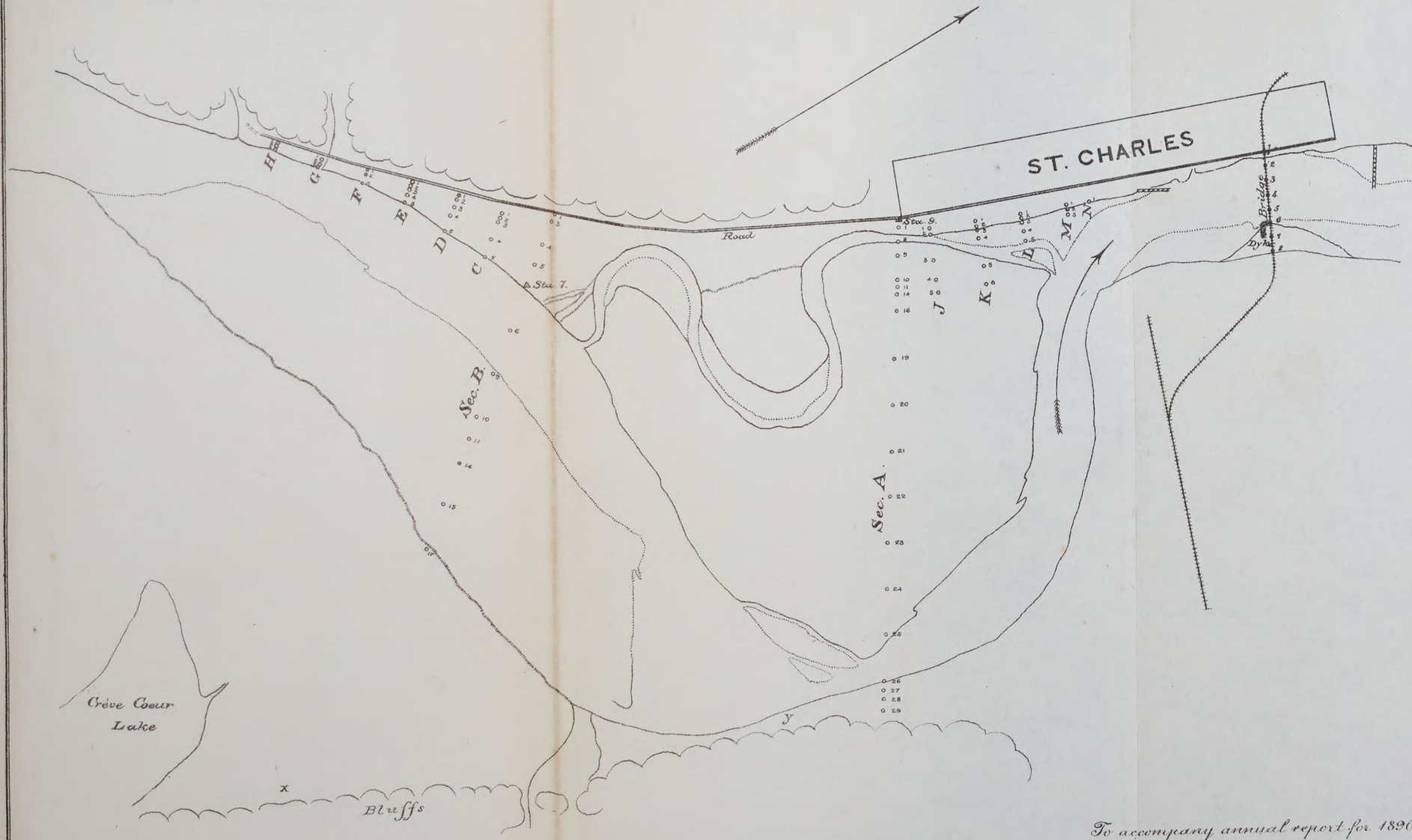
Pier III.—The material through which the caisson passed was entirely similar to that at Pier II, being a fine sand throughout to the clay at an elevation 1,581. The clay was of the same character as that found at Pier II, but the surface was more nearly uniform and the strata more regular and horizontal. At an average depth of 8 feet below the surface of the clay, a hard layer of marly rock about three-quarters of an inch thick was found which extended over the whole foundation."

Plate XXIII shows the location of the borings and the section plotted from them. The section possibly shows too much coarse sand and gravel, since the material above the clay was almost entirely fine sand.

SUPPLEMENTAL REPORT ON BORINGS IN THE MISSOURI VALLEY.

MISSOURI RIVER COMMISSION,
St. Louis, Mo., June 30, 1890.

SIR: I have the honor to submit the following report on borings in the Missouri Valley, supplementary to the report of Capt. Theo. A. Bingham, Corps of Engineers, of November 1, 1889, and containing such data on the subject as has been received



MISSOURI RIVER COMMISSION.

LOCATION

of

BORINGS

in vicinity of

ST. CHARLES, MO.,

made December 1880 to Feby. 1881.

Scale:

1000 0 1000 2000 3000 4000 Ft.

To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

MISSOURI RIVER COMMISSION.

ROCK PROFILES

in vicinity of

ST. CHARLES, MO.,

made

Dec. 1880. to Feb. 1881.

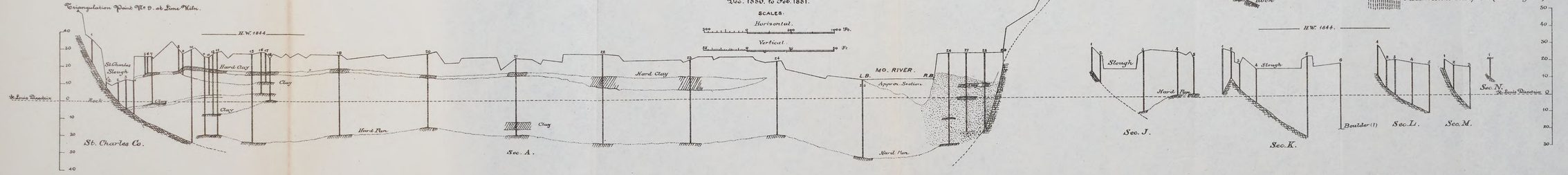
SCALES.

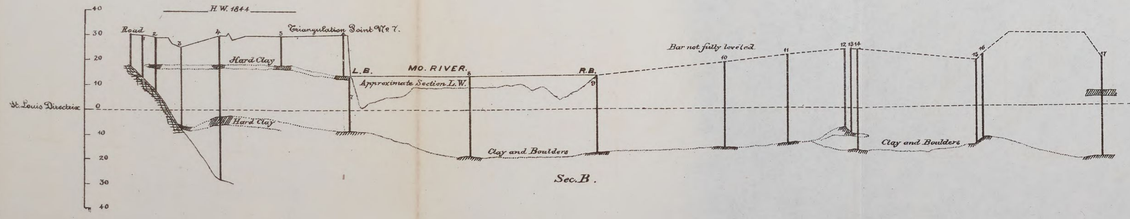
Horizontal. 200 0 200 400 Ft.

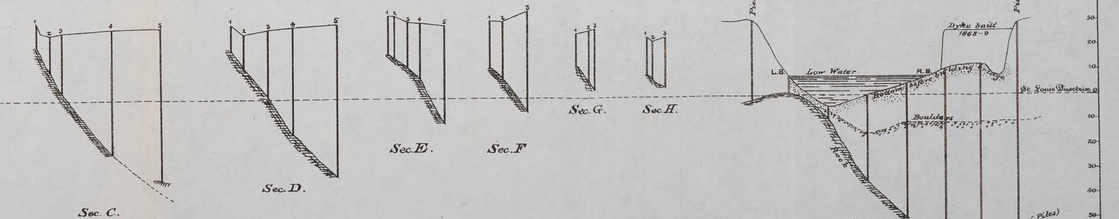
Vertical 0 20 30 Ft.

Conventional Signs

Sand
Gravel
Boulders
Rock
Slate & Shale
Gumbo & Silt
Clay
Modern Alluvial Deposit (not analyzed)







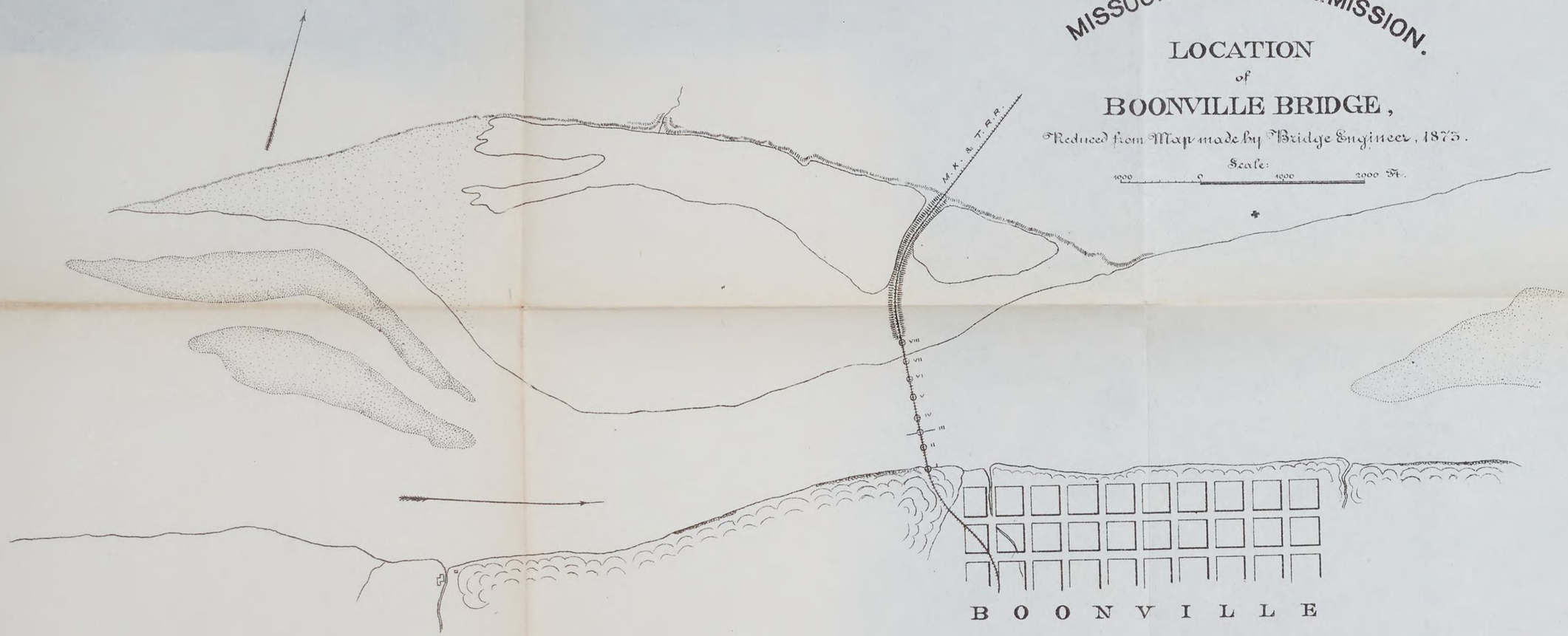
To accompany annual report for 1880 of the Sec'y. Mo. River Commission.

MISSOURI RIVER COMMISSION.

LOCATION
of
BOONVILLE BRIDGE,

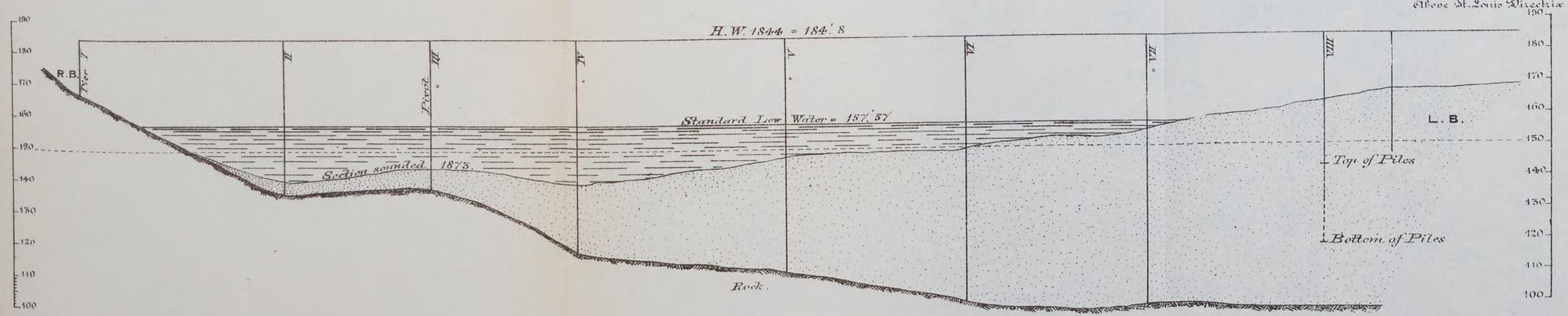
Reduced from Map made by Bridge Engineer, 1875.

Scale:
1000 0 1000 2000 Ft.



ROCK PROFILE
on Line of Bridge at
BOONVILLE, MO.

Scale:
100 0 100 200 Ft.
Horizontal.



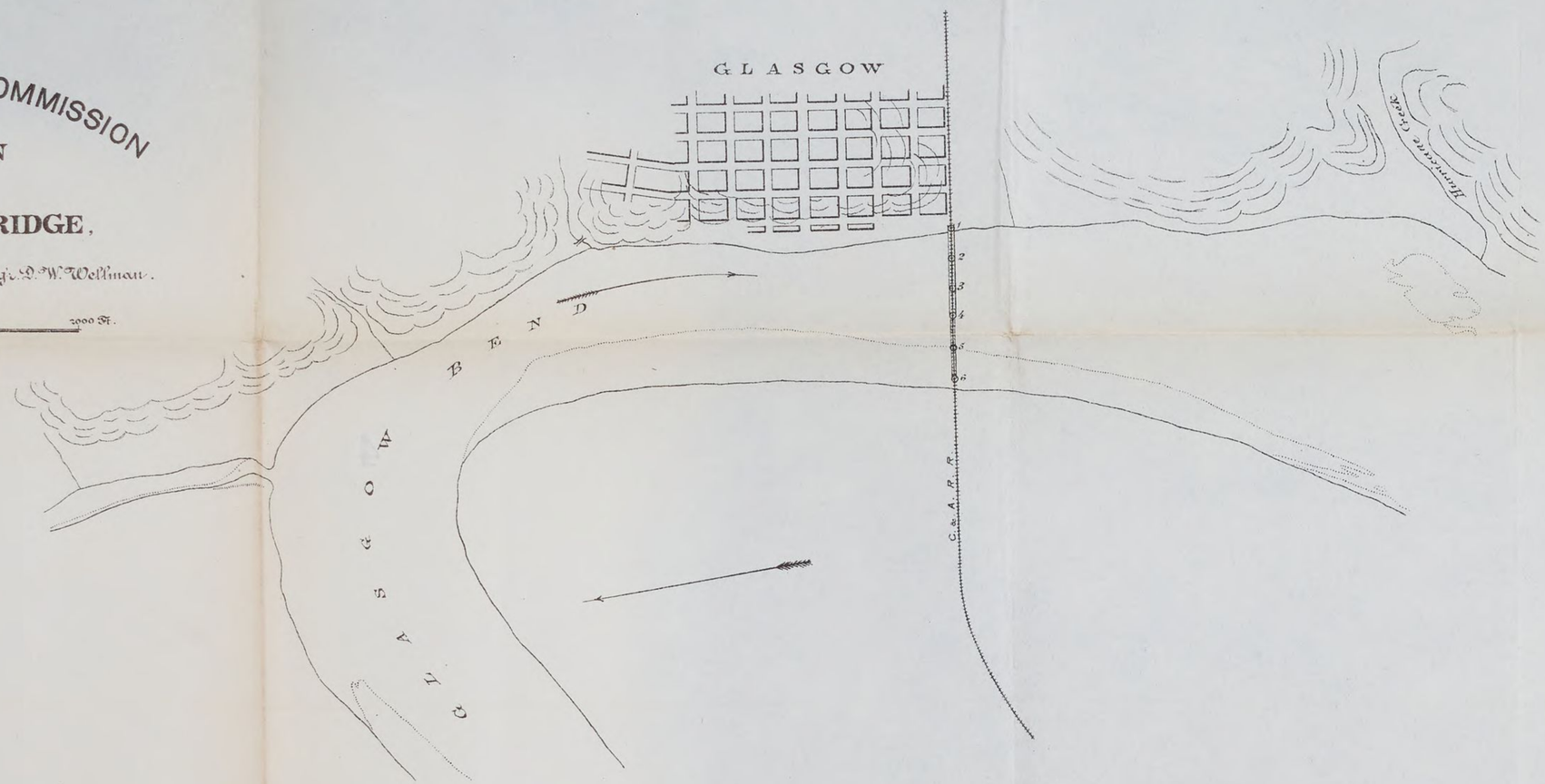
To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

MISSOURI RIVER COMMISSION

LOCATION
of
GLASGOW BRIDGE,

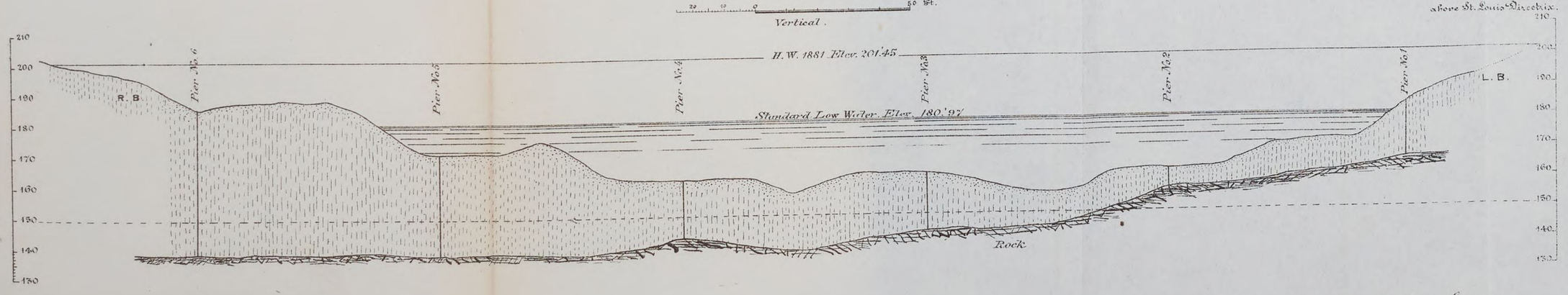
surveyed Nov. 1878 by Asst. Engr. D. W. Wellman.

Scale:
1000 0 1000 2000 Ft.

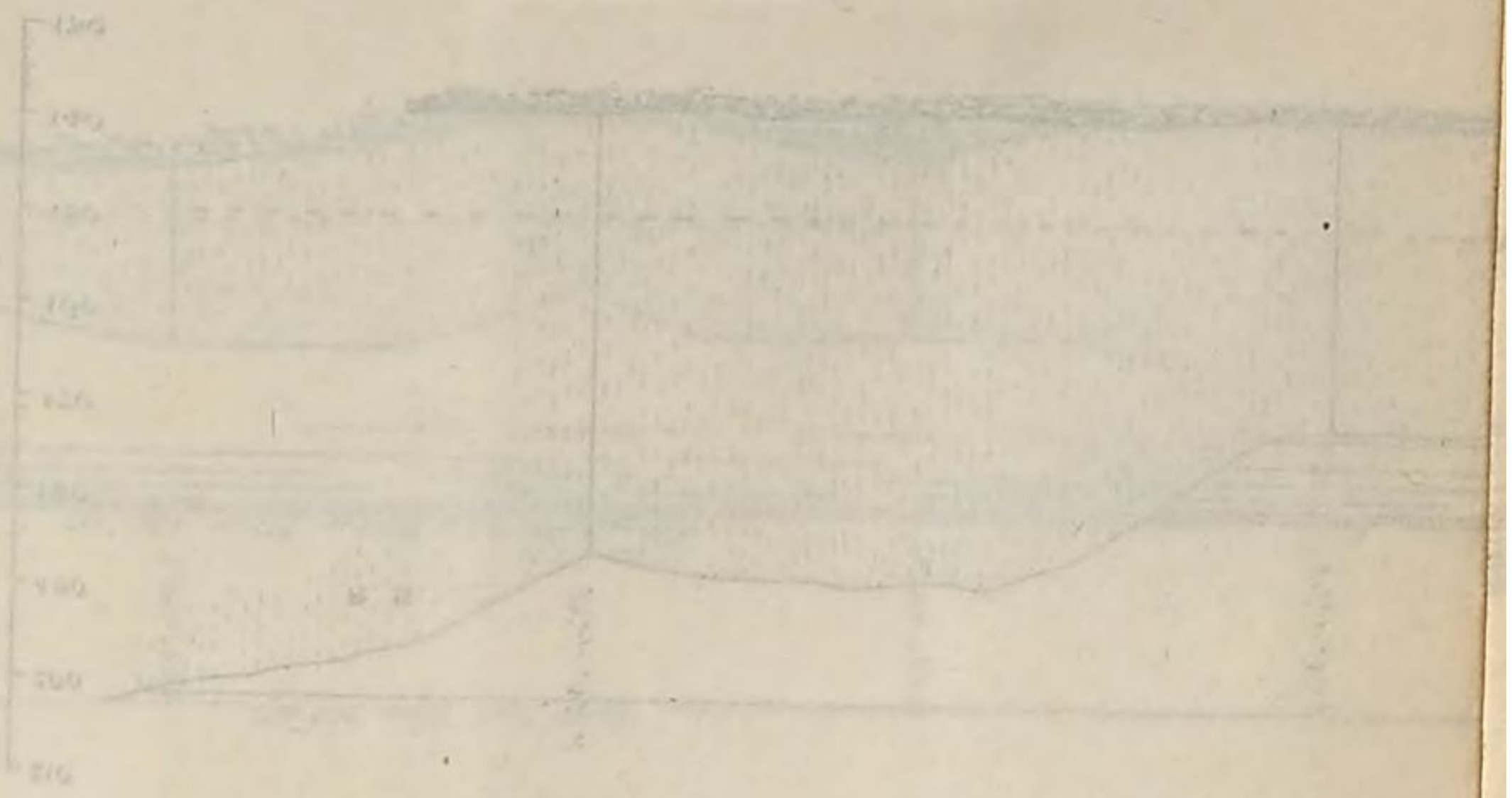


ROCK PROFILE,
on Line of Bridge at
GLASGOW, MO.

Scales:
100 0 100 200 Ft.
Horizontal.
20 10 0 50 Ft.
Vertical.



To accompany annual report for 1890 of the Sec'y. Mo. River Commission.



MISSOURI RIVER COMMISSION

LOCATION

GLASGOW BRIDGE

MISSOURI RIVER COMMISSION.

LOCATION

of

BORINGS

in vicinity of

SIBLEY, MO.

made in 1886-7.

Scale:

400 0 400 800 1200 Ft.

B

III

A

High water line of 1881.

Slough

Low Bottom Land

Line of Profile — — — Borings C, D, E & F are close to this line

U.S. 113

Ordinary overflow

Boring No 2

Boring No 5

Well No 3

II

High water overflow

Boring No 1

8

7

6

U.S. 111

Boring "b"

Boring No 3

V

Boring "m"

Boring No 4

5

Boring "l"

4

Low Water Channel

Boring "c"

Boring "f"

3

VII

Boring "a"

Well No 1

Boring No 7

Boring "d"

Boring "g"

2

I

High water line of 1881

1

IV

Landing 1880

Old Well

High water line of 1881

VI

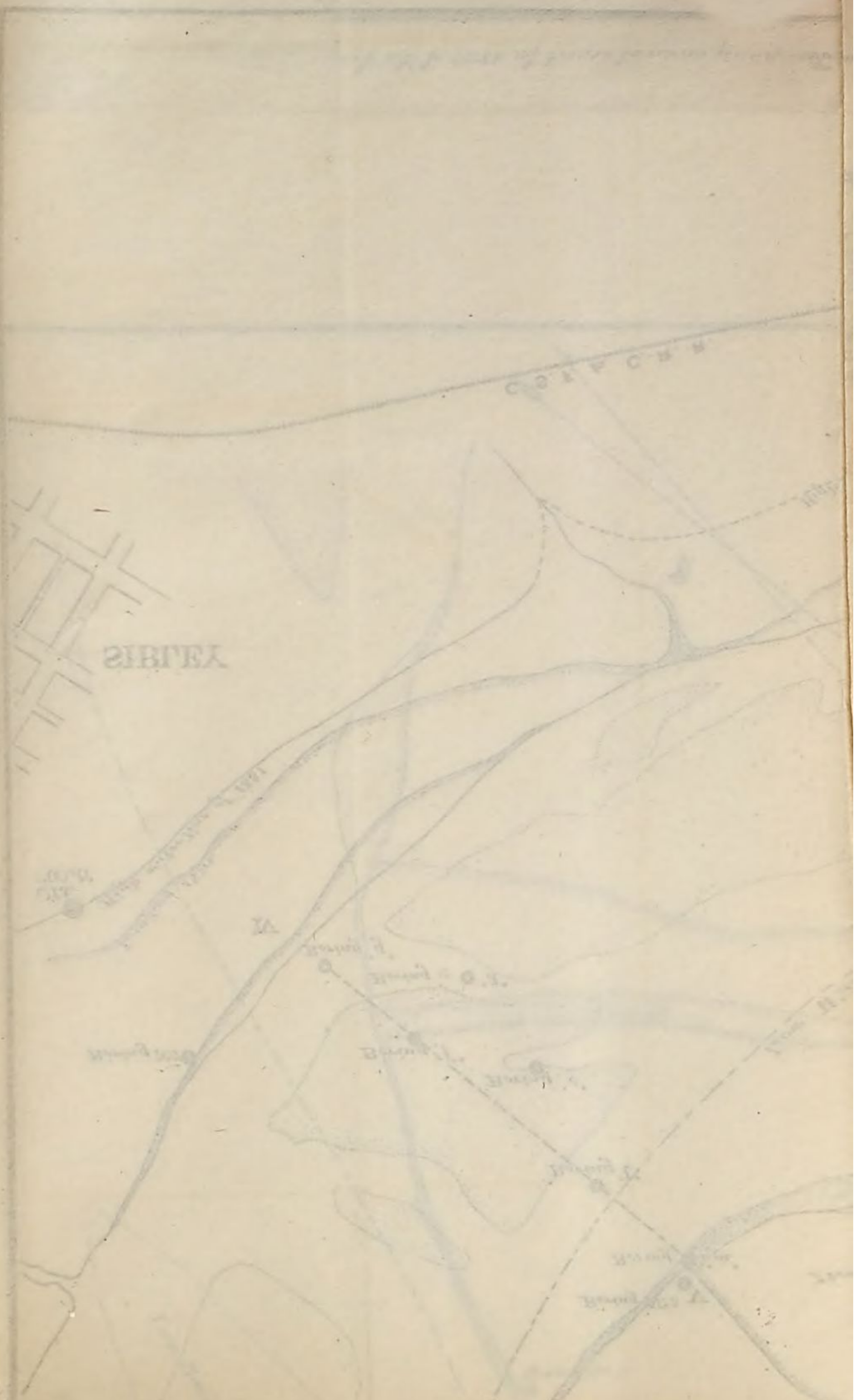
Well No 2

SIBLEY

High Water Line of 1881

C. S. F. & C. R. R.

To accompany annual report for 1890 of the Sec'y. Mo. River Commission.



MISSOURI RIVER COMMISSION.

ROCK PROFILE

on Line of Bridge

at

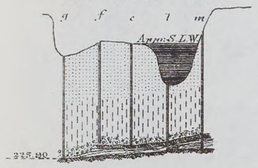
SIBLEY, MO.

Scale:

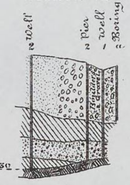
1000 0 1000 2000 Ft.

Horizontal.

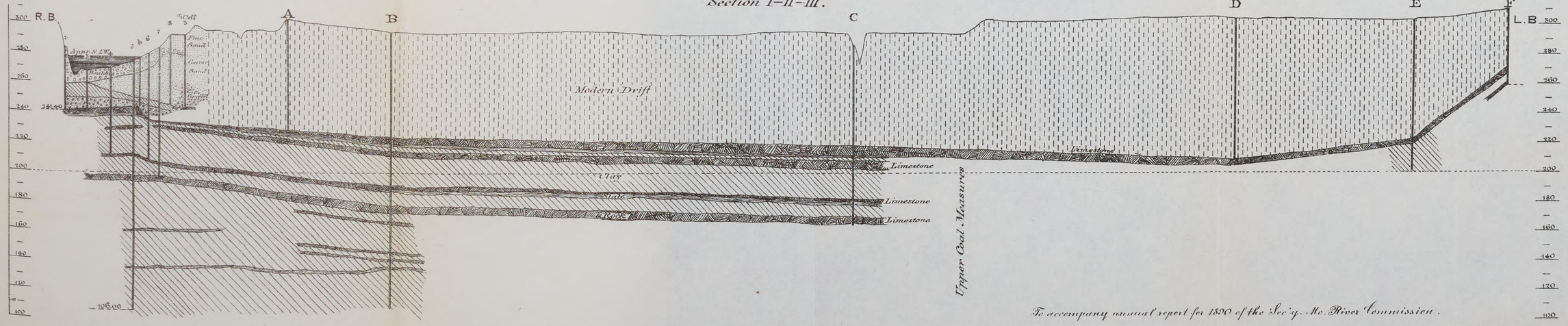
Section IV–V.



Section VI–VII.

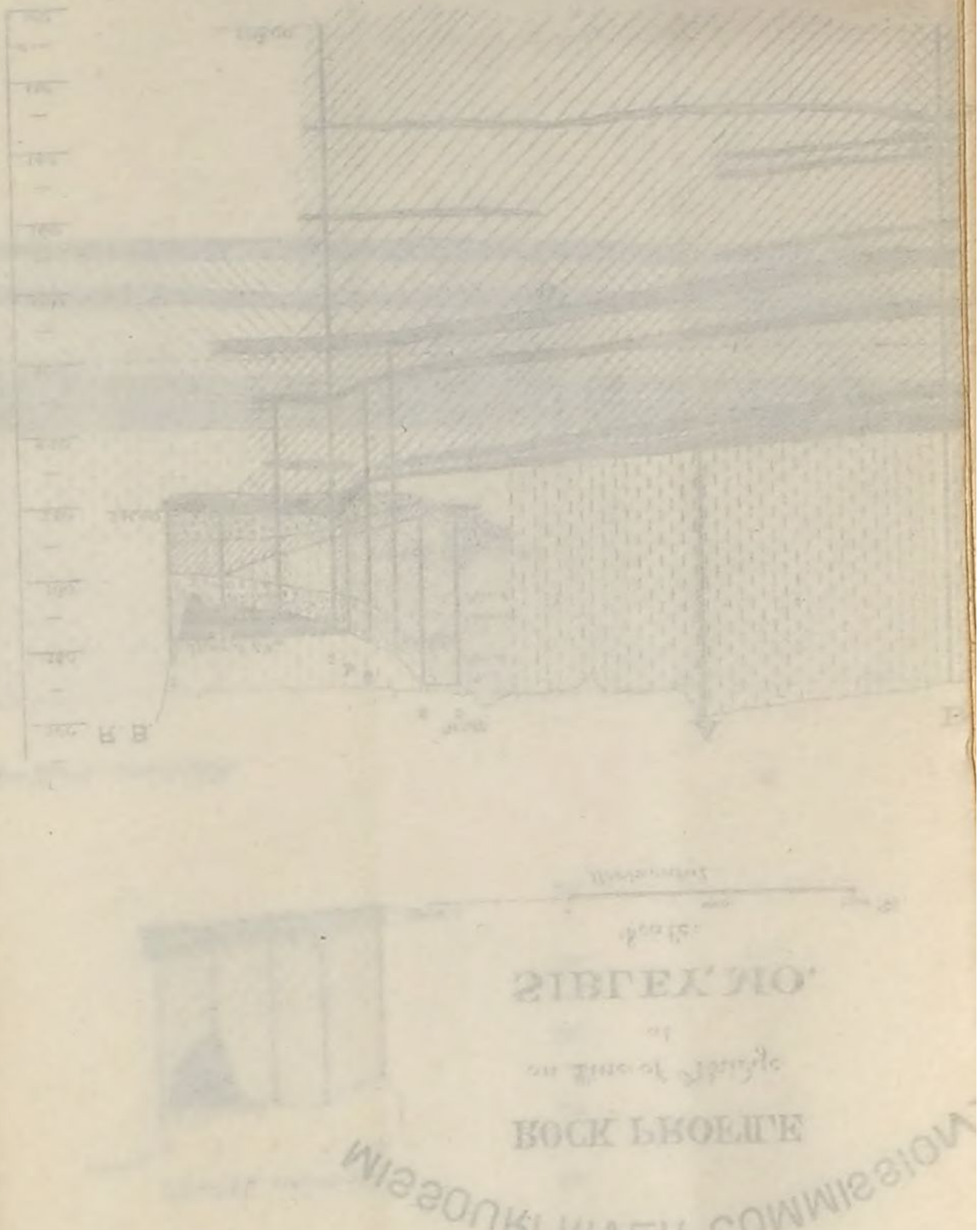


Section I–II–III.

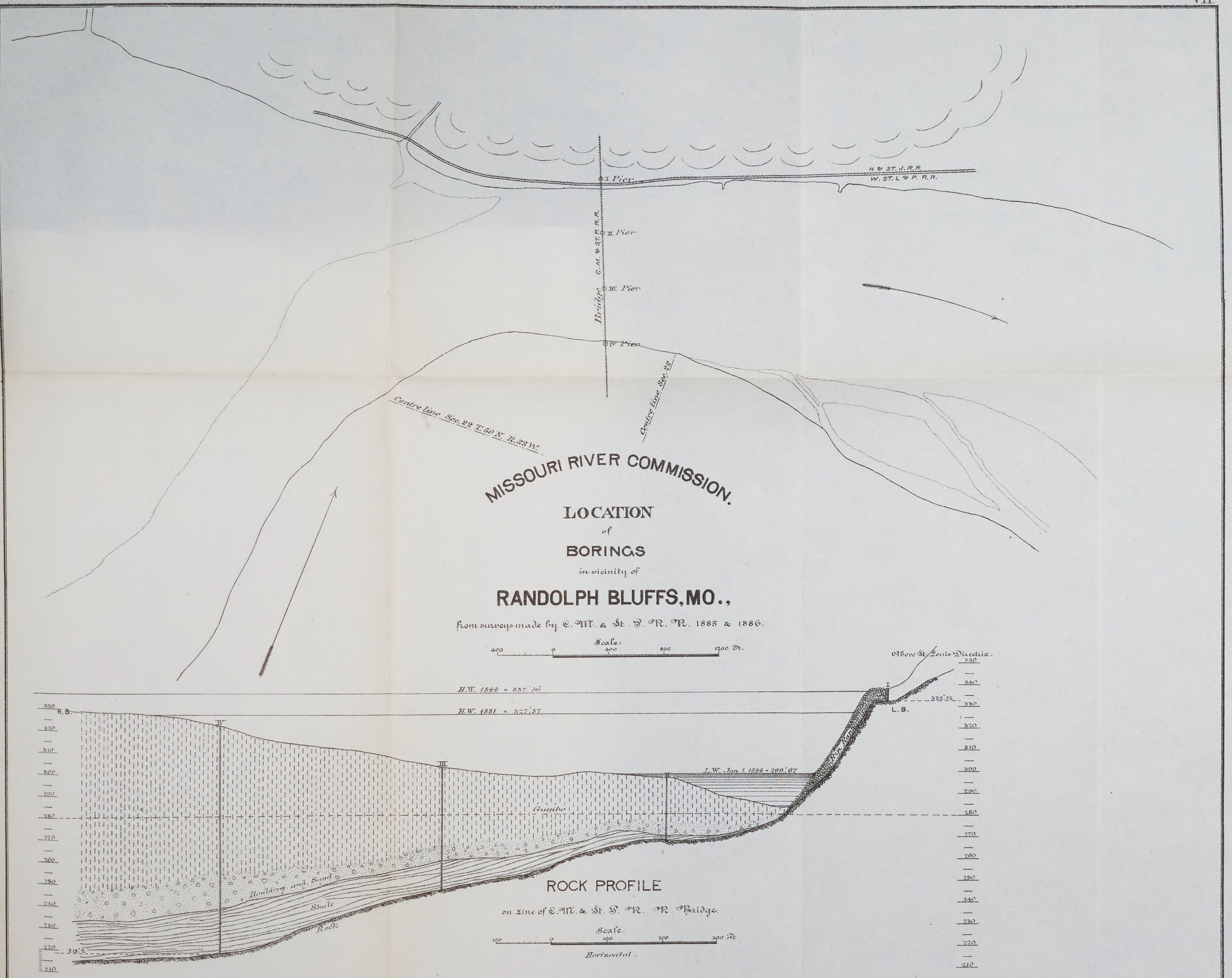


To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

Eng 90



MISSOURI STATE COMMISSION



MISSOURI RIVER COMMISSION.

LOCATION
of
BORINGS
in vicinity of
RANDOLPH BLUFFS, MO.,

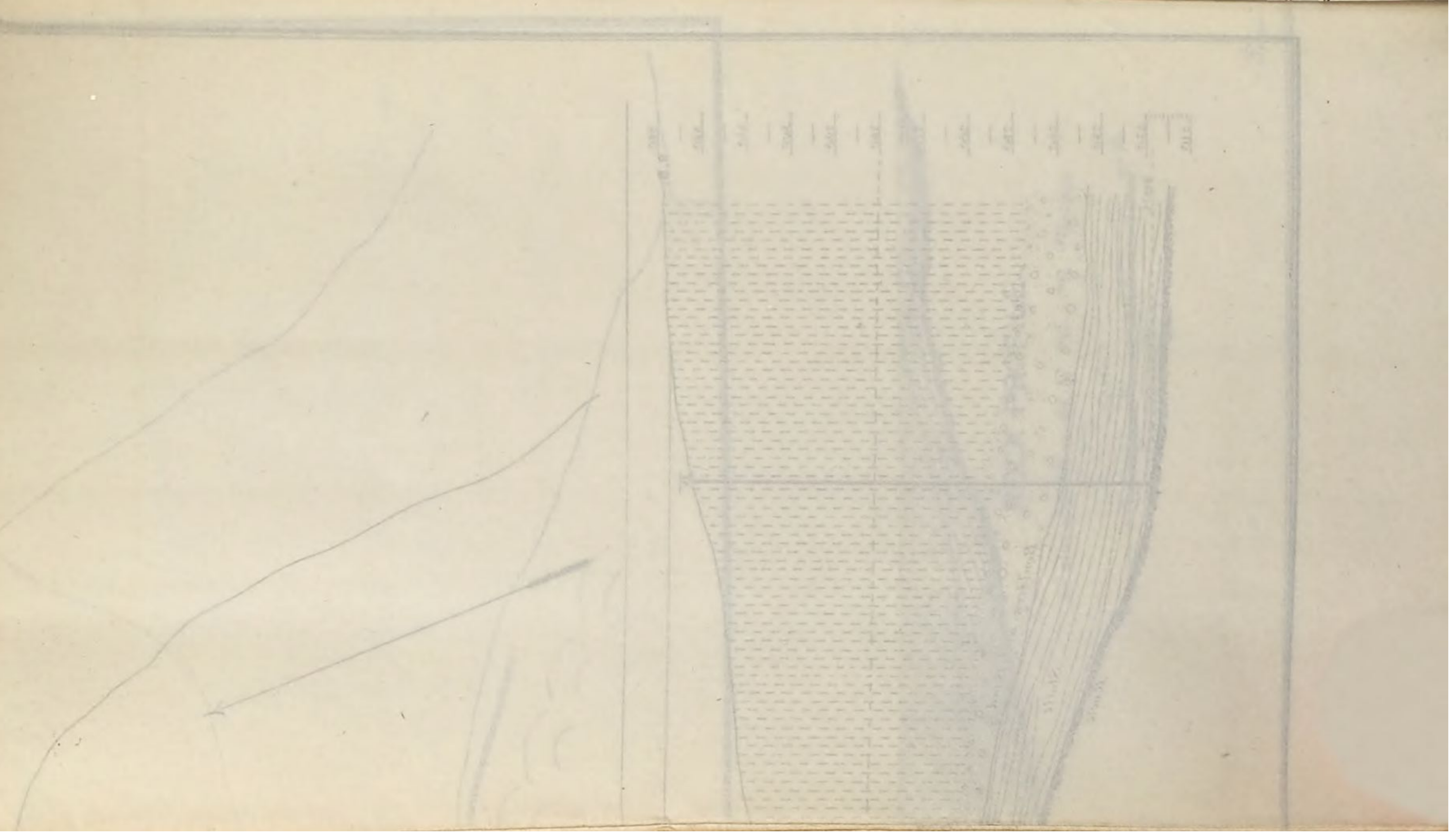
from surveys made by C. M. & St. P. R. R. 1885 & 1886.

ROCK PROFILE

on Line of C. M. & St. P. R. R. Bridge.

Scale.
100 0 100 200 300 Ft.
Horizontal.

To accompany annual report for 1890 of the Sec'y. Mo. River Commission.



MISSOURI RIVER COMMISSION.

LOCATION

of

BORINGS

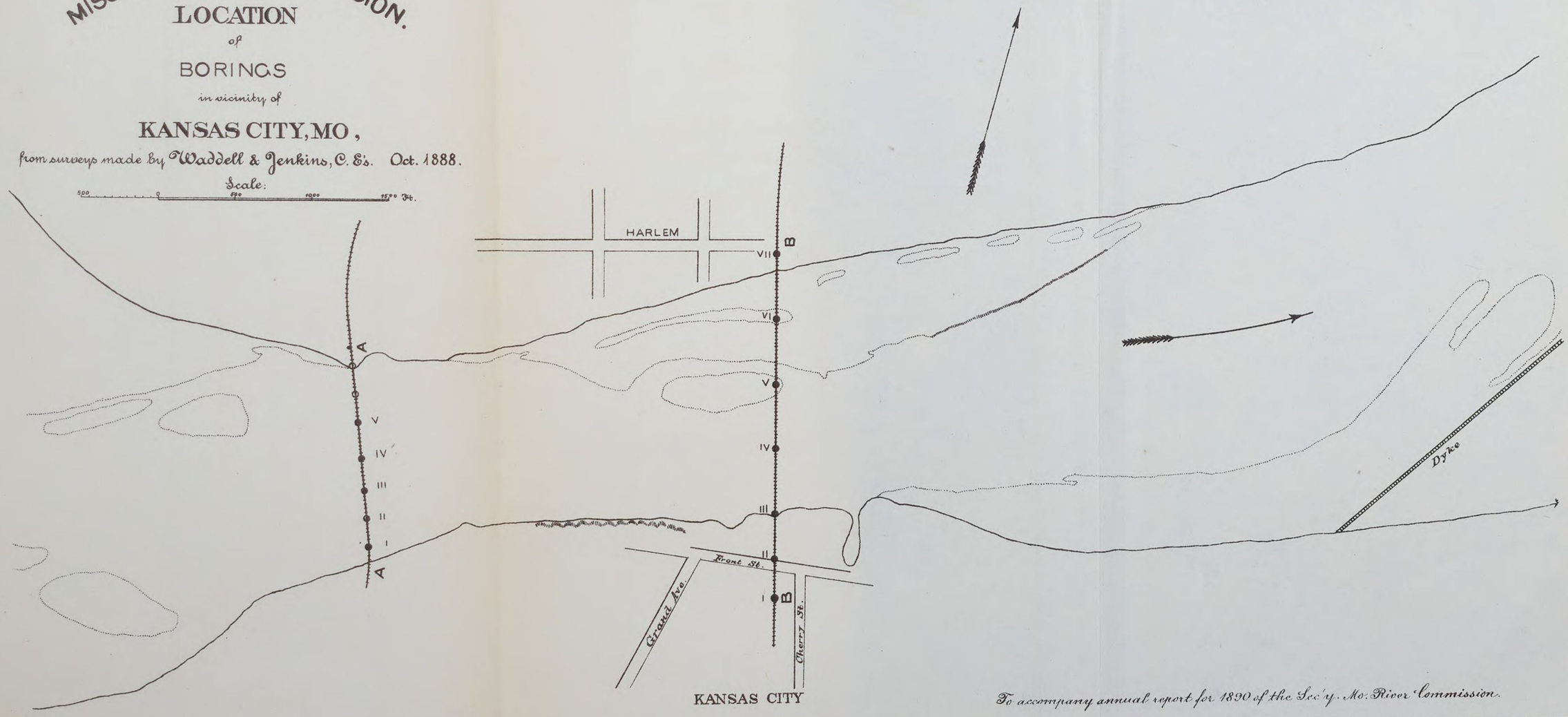
in vicinity of

KANSAS CITY, MO,

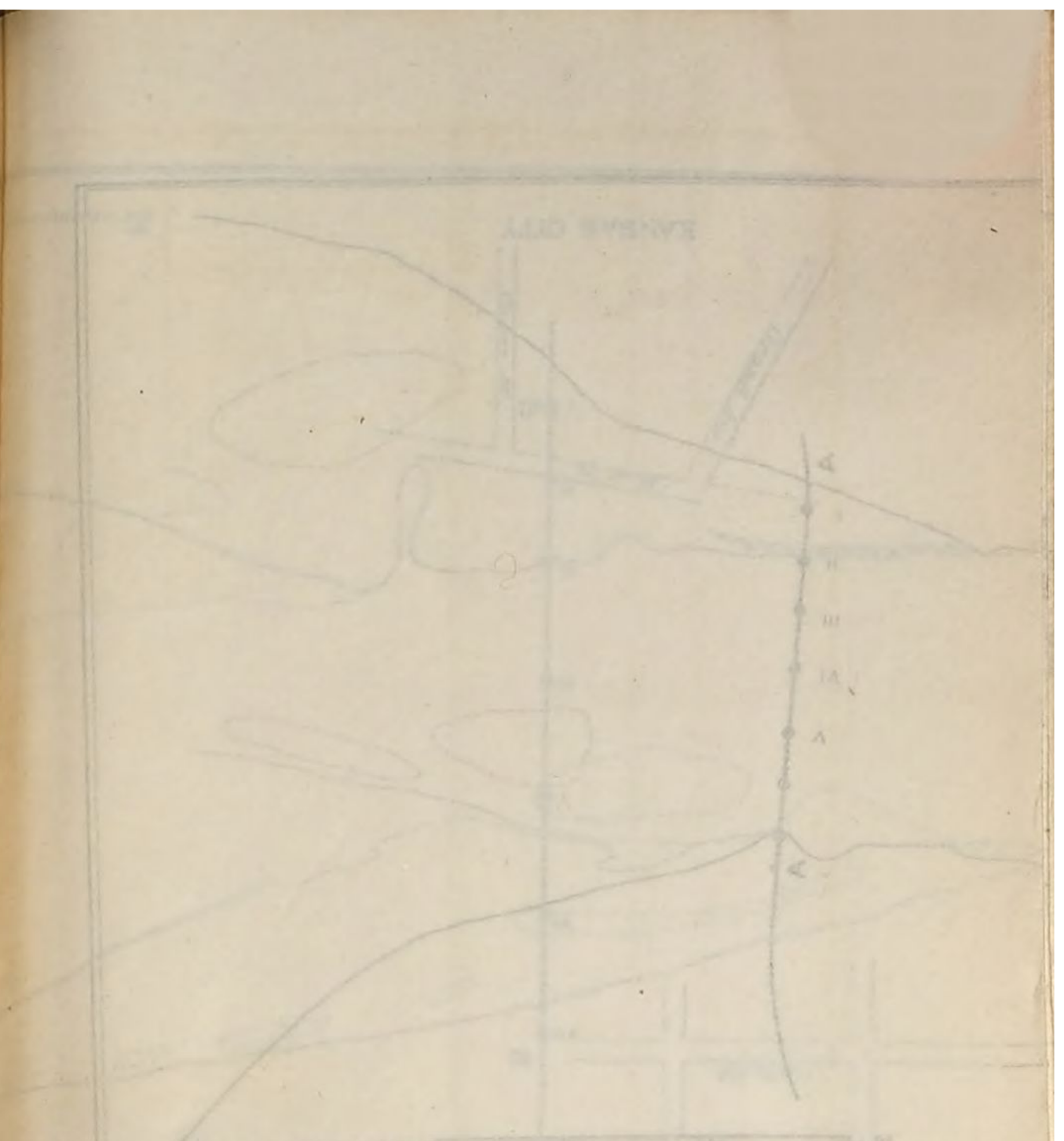
from surveys made by Waddell & Jenkins, C. E's. Oct. 1888.

Scale:

500 0 500 1000 1500 Ft.



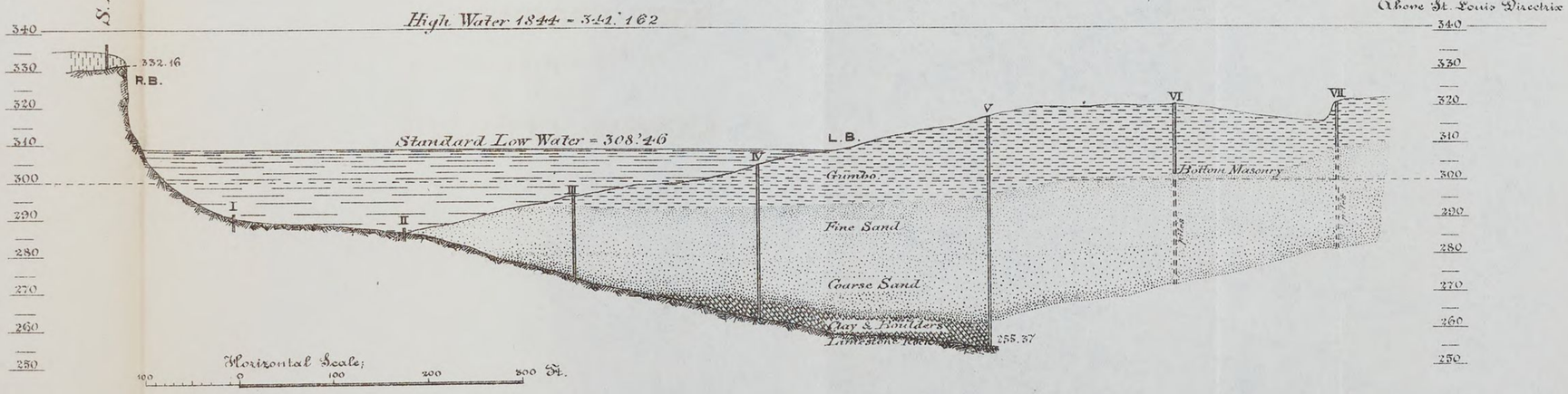
To accompany annual report for 1890 of the Sec'y. Mo. River Commission.



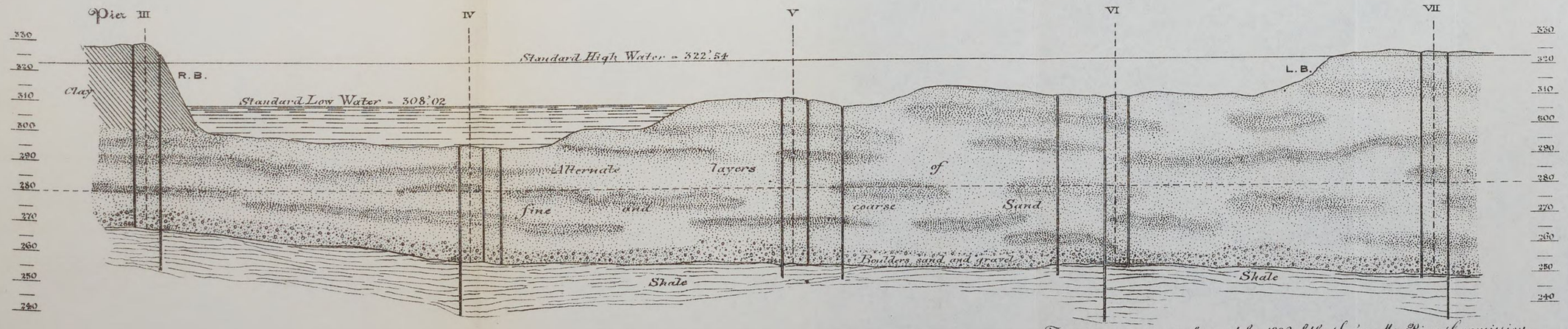
MISSOURI RIVER COMMISSION.

ROCK PROFILES
on Bridge Lines
at
KANSAS CITY, MO.

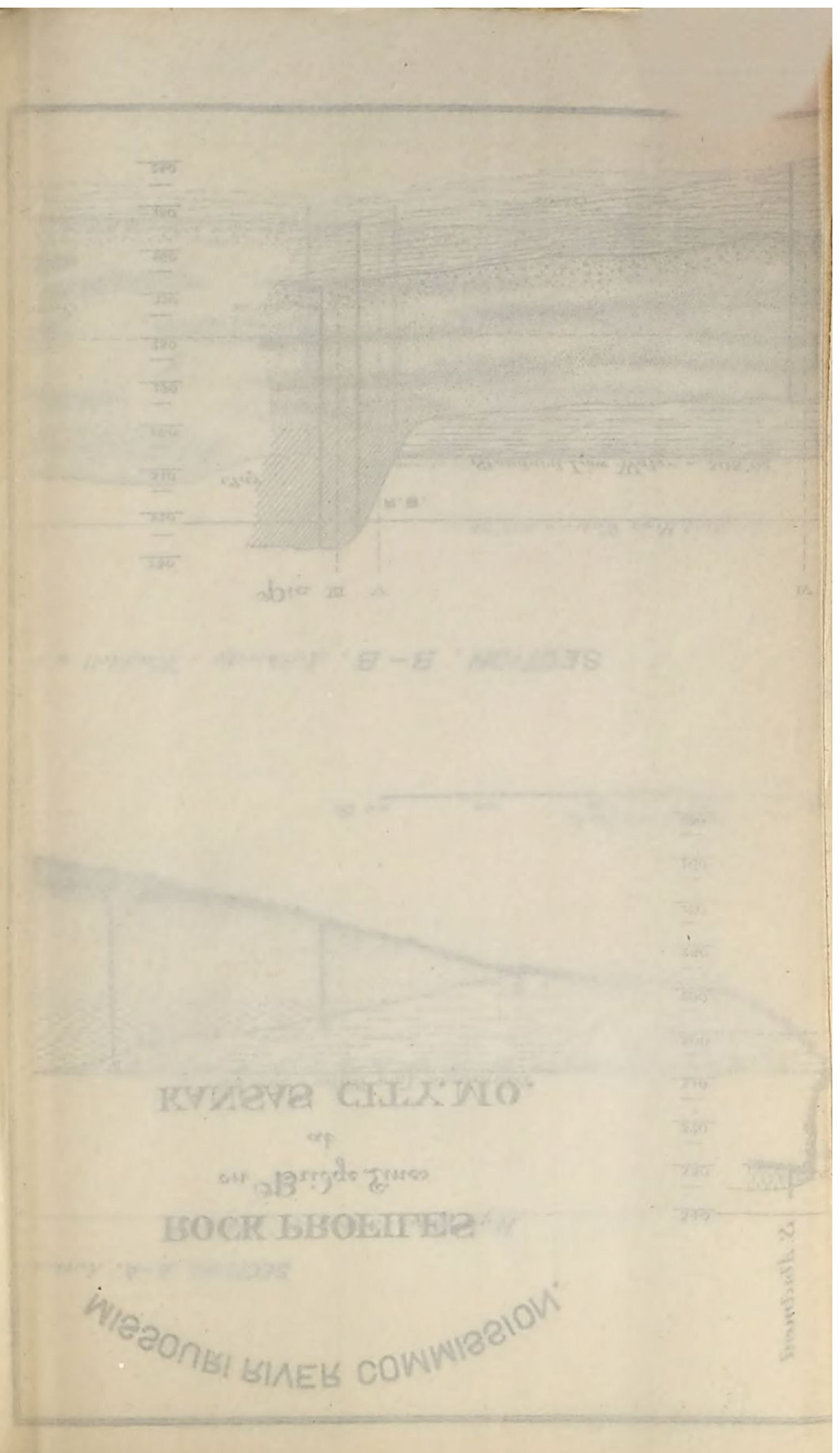
SECTION, A-A. Authority: Chanute & Morison.



SECTION, B-B. Authority: Waddell & Jenkins.



To accompany annual report for 1890 of the Sec'y. Mo. River Commission.



MISSOURI RIVER COMMISSION

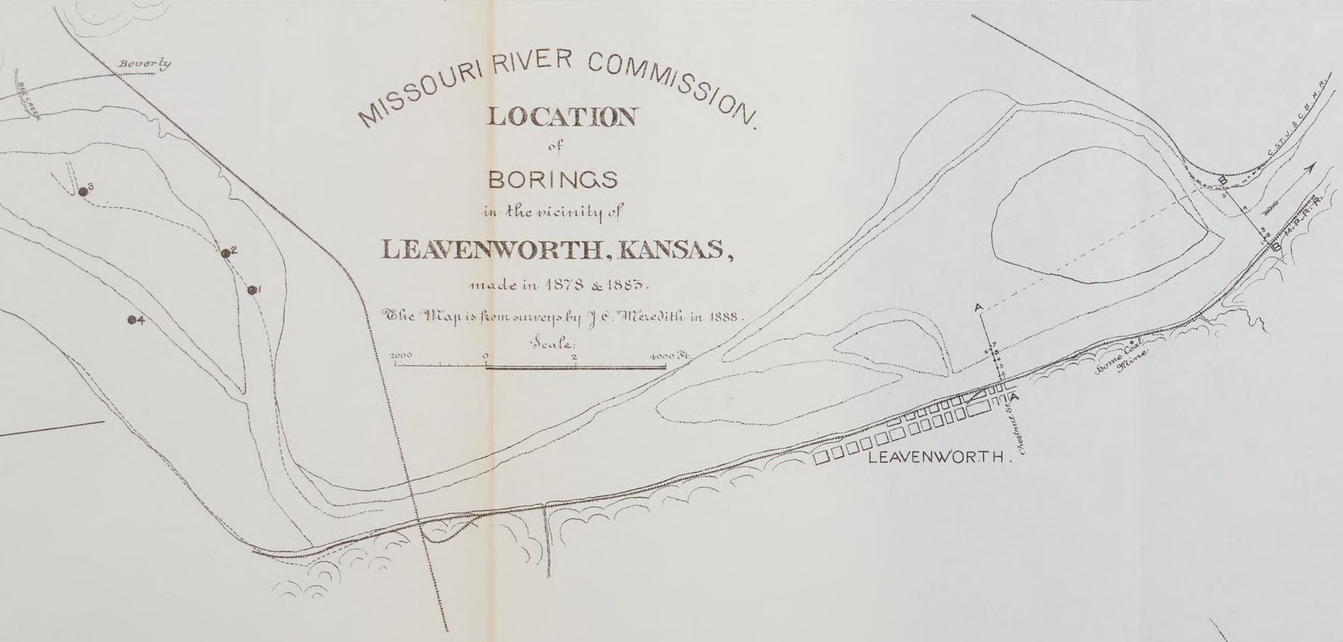
MISSOURI RIVER COMMISSION.

LOCATION
of
BORINGS
in the vicinity of
LEAVENWORTH, KANSAS,

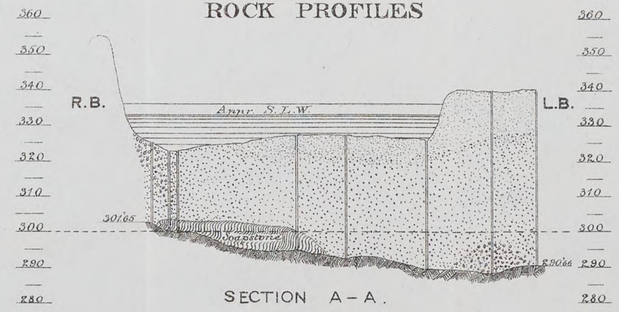
made in 1878 & 1883.

The Map is from surveys by J. C. Meredith in 1888.

Scale.

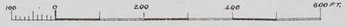


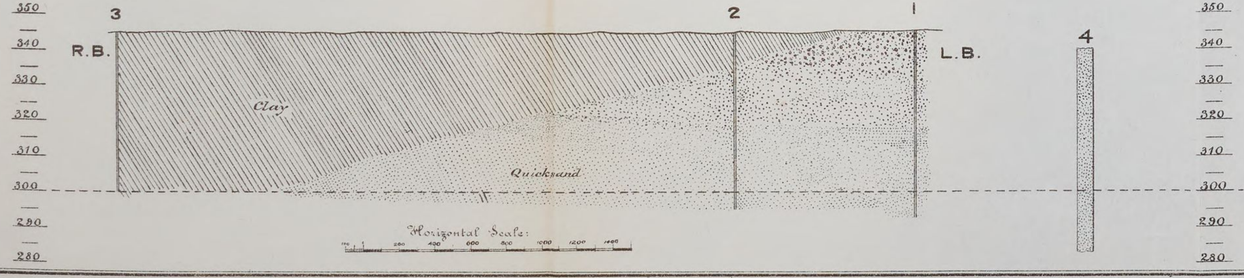
ROCK PROFILES

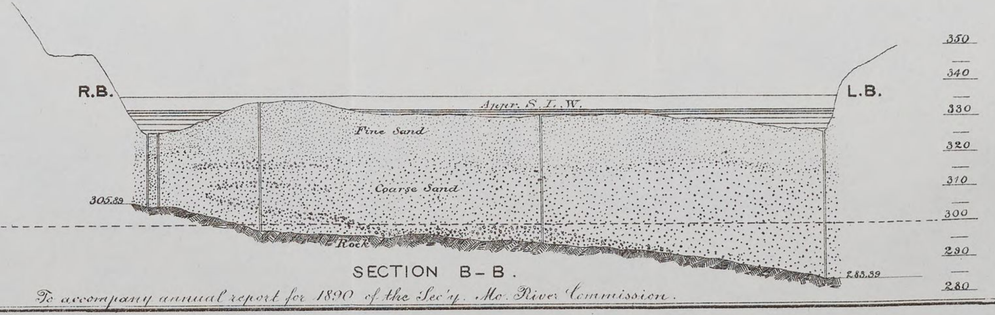


SECTION A – A.

Horizontal Scale, Sections A-A & B-B.

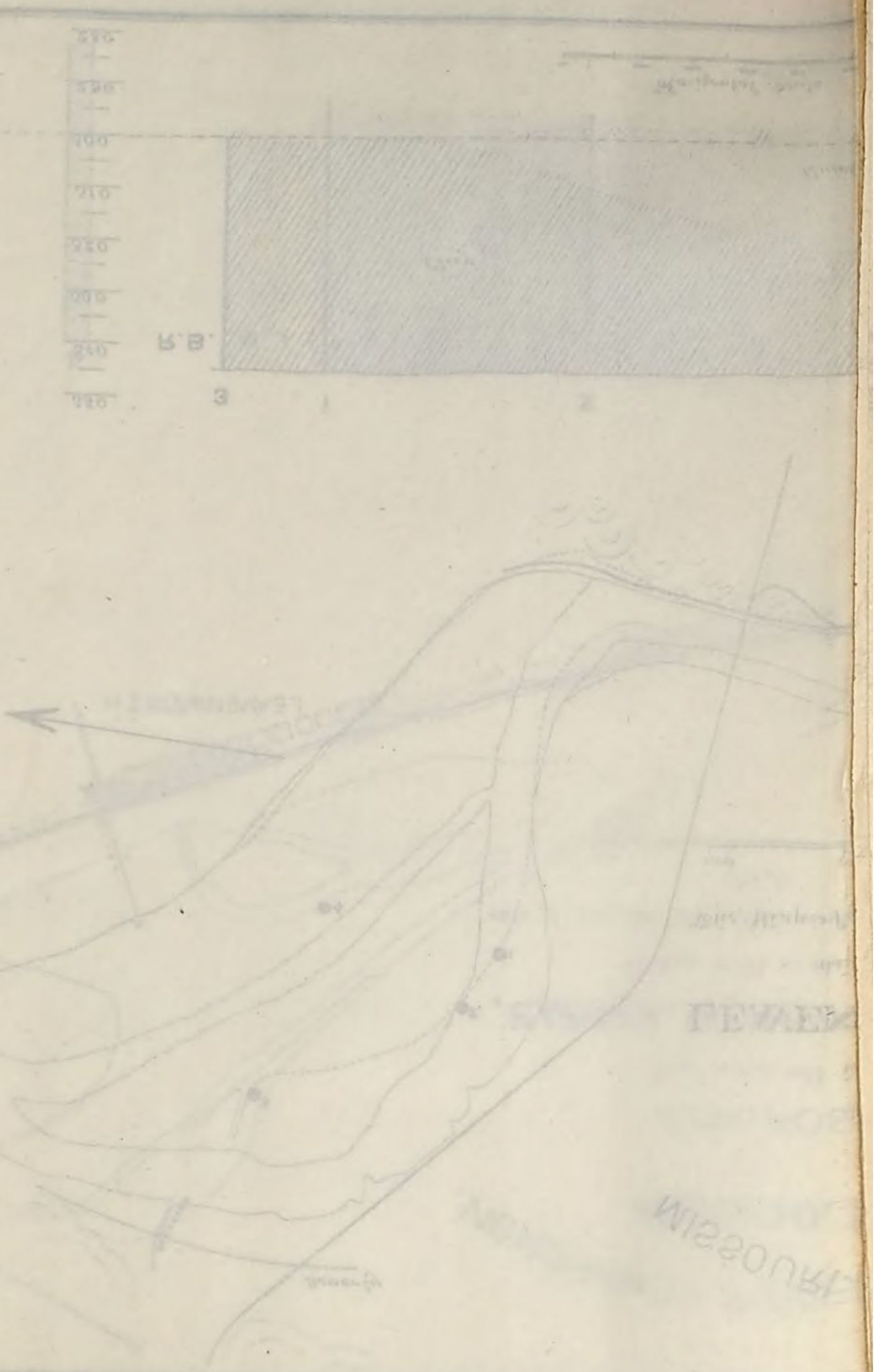




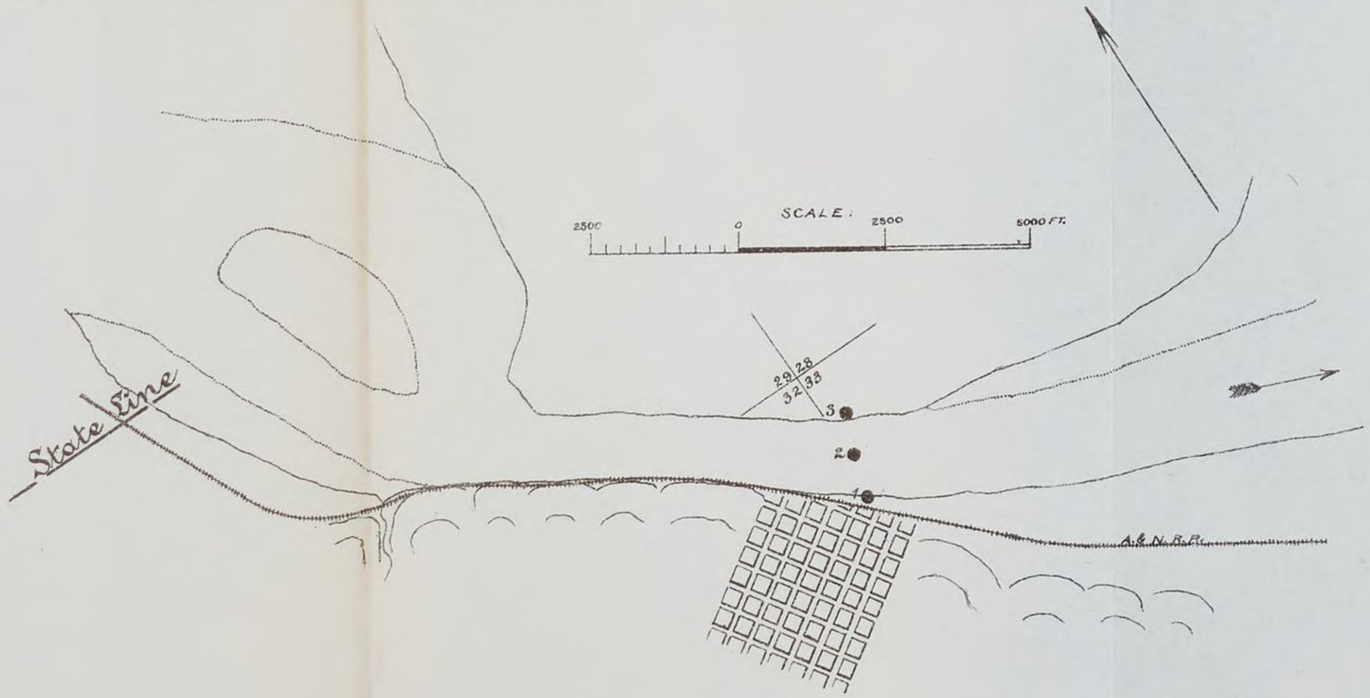


SECTION B – B.

To accompany annual report for 1890 of the Sec'y. Mo. River Commission.



11



MISSOURI RIVER COMMISSION.

LOCATION

of

BORINGS

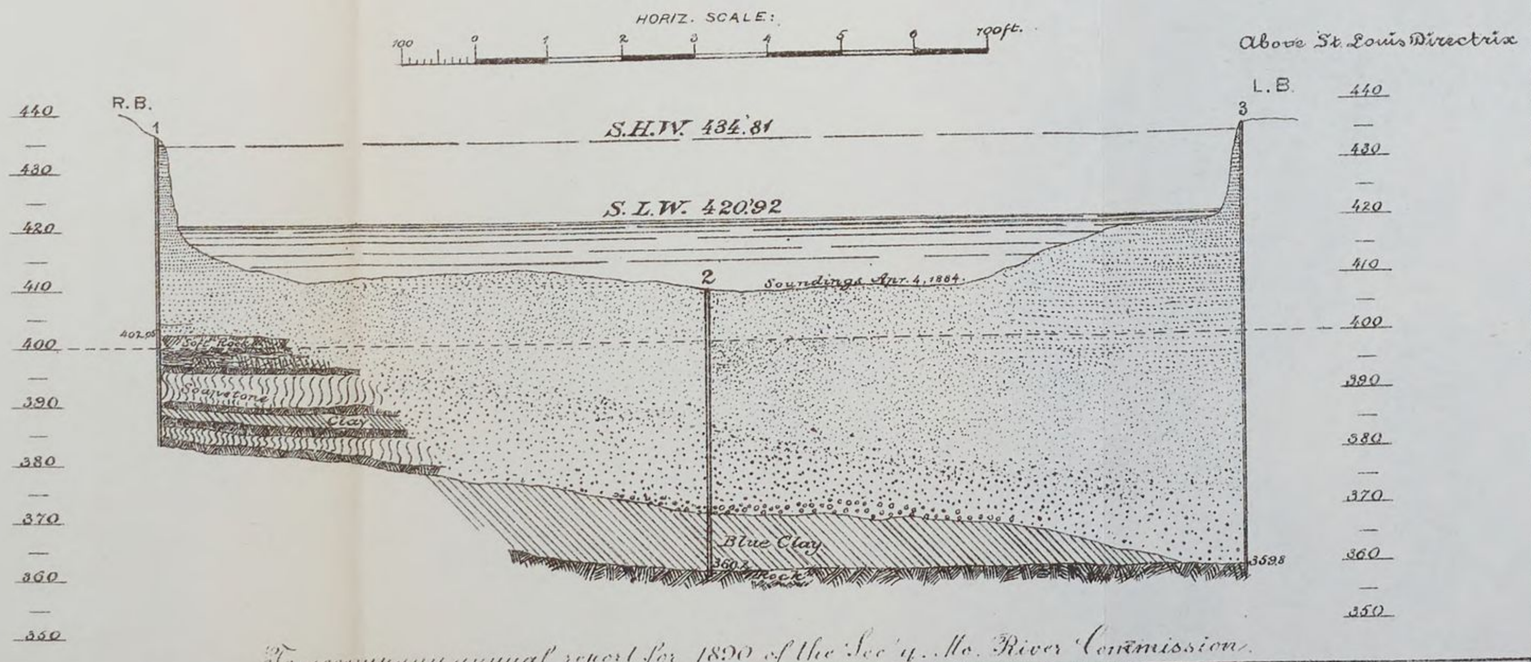
Made in the vicinity of

WHITE CLOUD, KAS.,

1884,

by Geo. S. Morison.

Rock Profile.



To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

MISSOURI RIVER COMMISSION

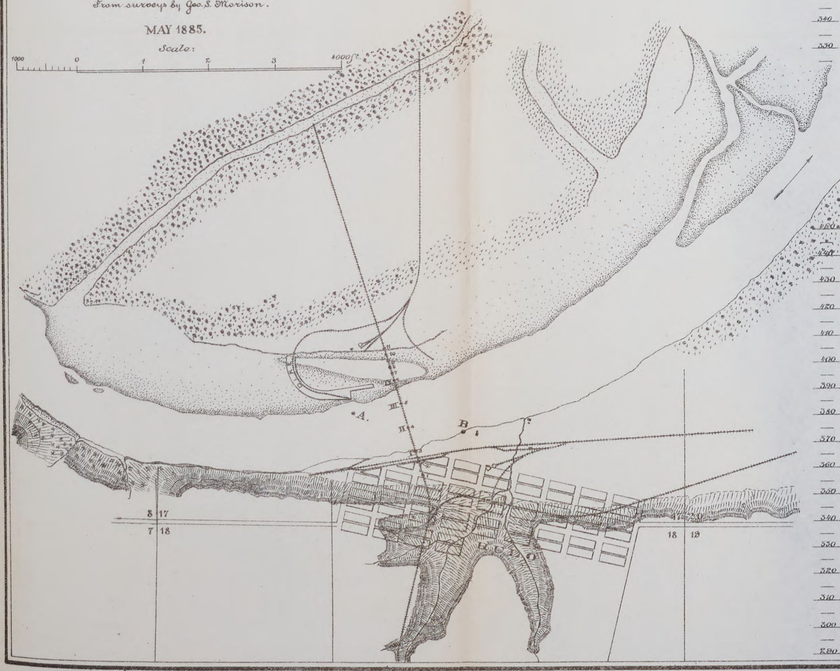
MISSOURI RIVER COMMISSION.

LOCATION
of
BORINGS
In the vicinity of
RULO, NEB.,

From surveys by Geo. S. Morison.

MAY 1885.

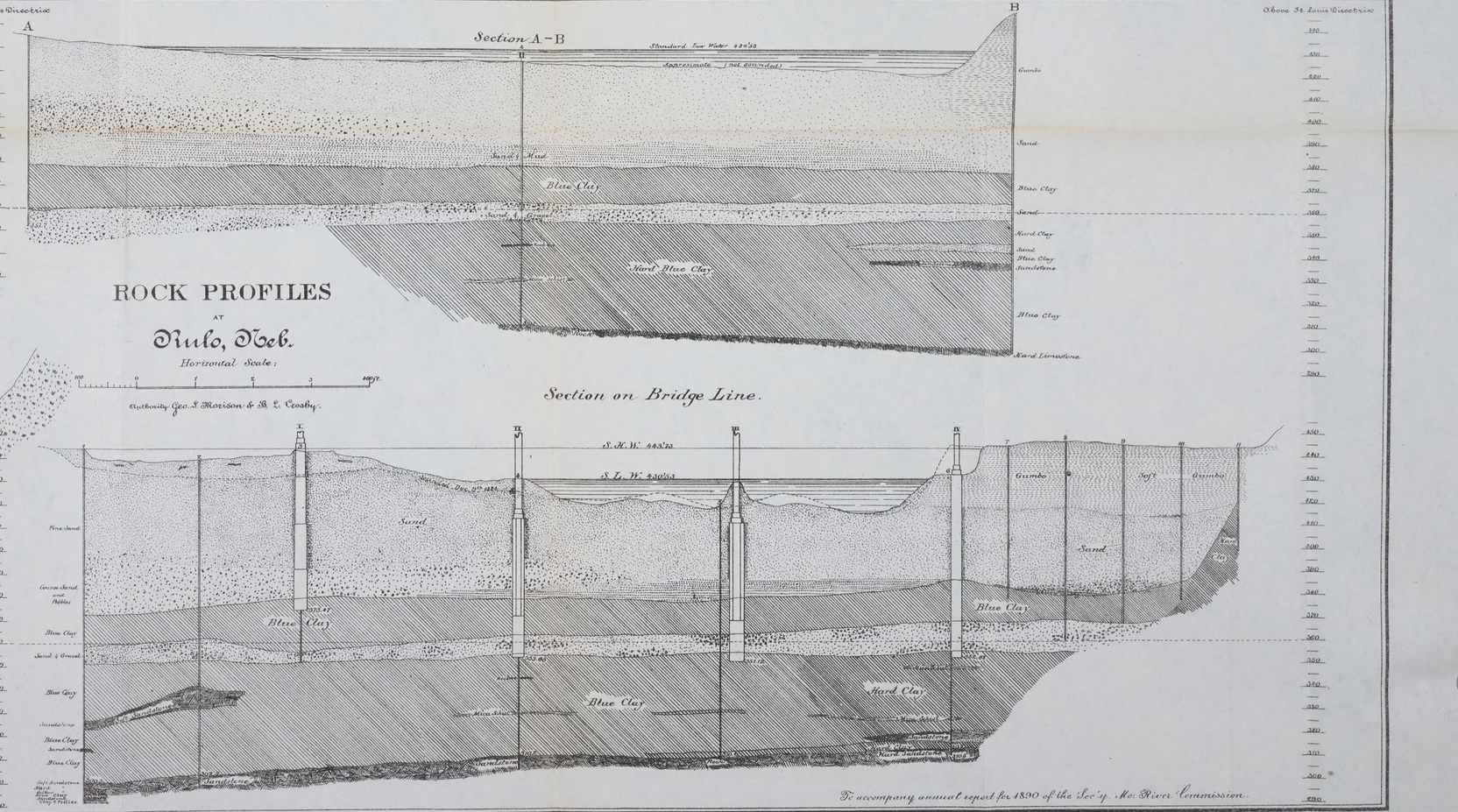
Scale:



ROCK PROFILES
AT
Rulo, Neb.

Horizontal Scale:

Authority Geo. S. Morison & R. L. Crosby.



To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

RECEIVED
MISSISSIPPI RIVER COMMISSION
VICKSBURG, MISS.

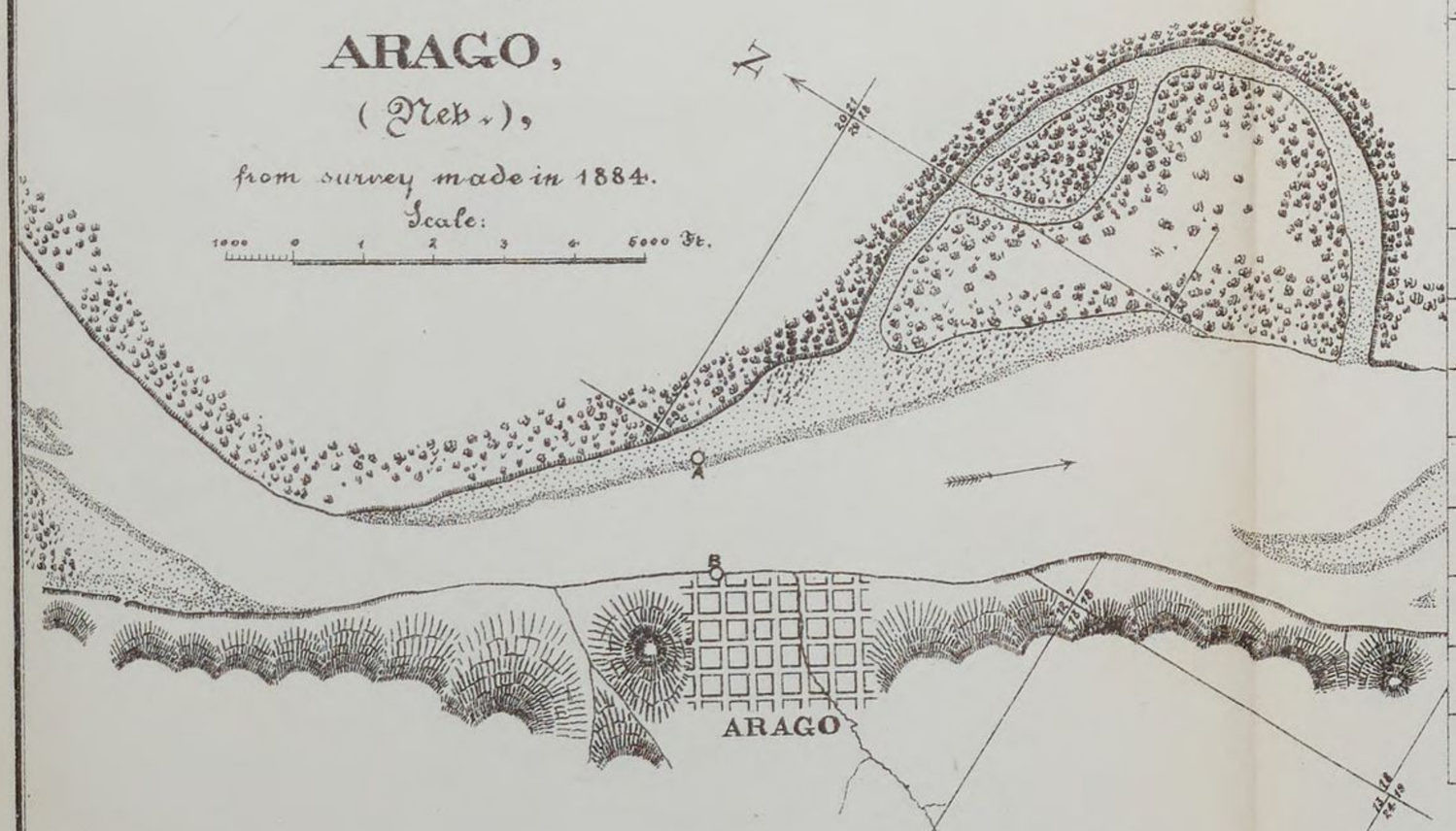
MISSOURI RIVER COMMISSION.

LOCATION
of
BORINGS
in the vicinity of
ARAGO,
(Nebr.),

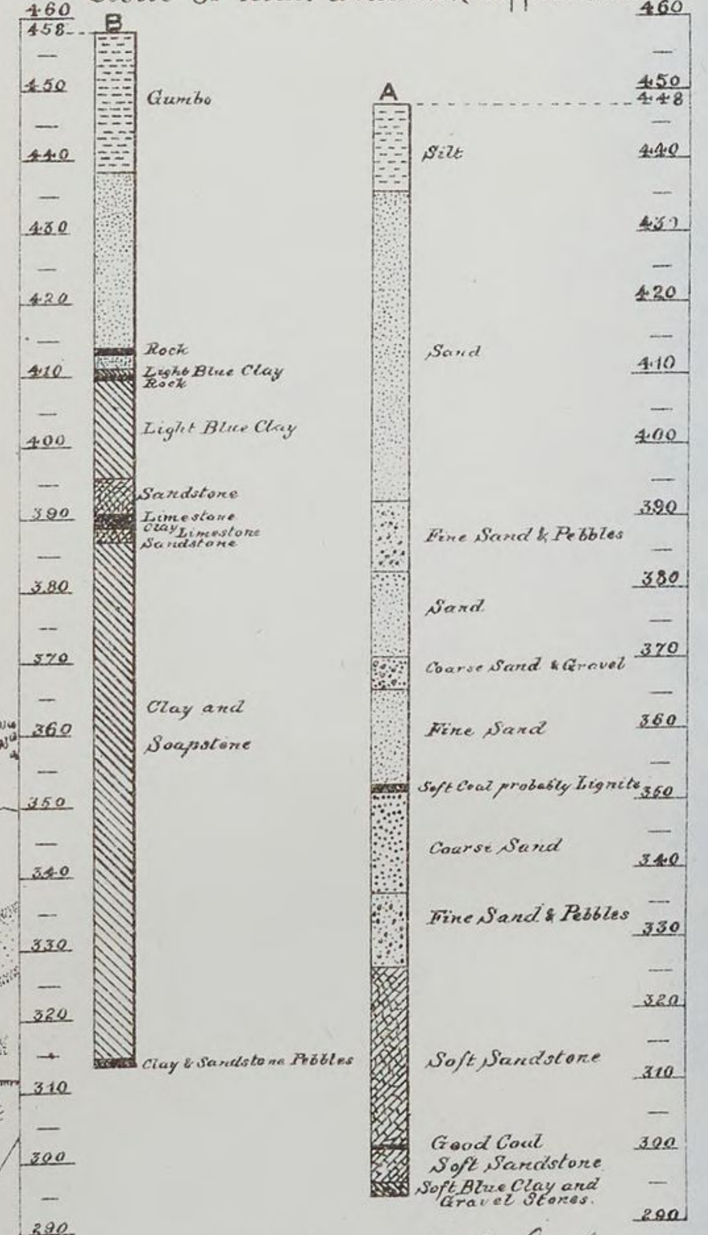
from survey made in 1884.

Scale:

1000 0 1 2 3 4 5000 Ft.



Above St Louis Directrix. (Approximate)



Authority: B. L. Crosby.

To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

Eng 90

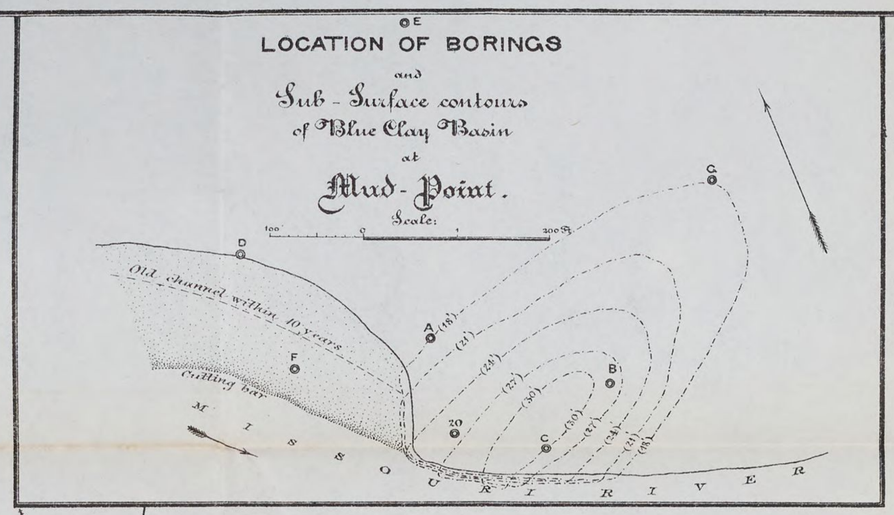
MISSOURI RIVER COMMISSION.

LOCATION of BORINGS in the vicinity of NEBRASKA CITY, NEB.,

from survey made in 1879.

Scale: 1000 0 1 2 3 4 5000 Ft.

NOTE The broken lines (- - - - - - - -) are from survey of 1889.



ROCK PROFILE on Bridge Line.

To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

ROCK PROFILE

MISSOURI RIVER COMMISSION.

ROCK PROFILES

in vicinity of

NEBRASKA CITY, NEB.,

from

BORINGS MADE 1879.

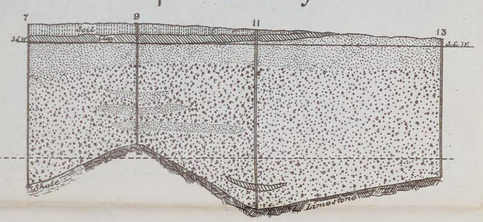
By E. H. Wilson Asst. Engr.

Horizontal Scale:

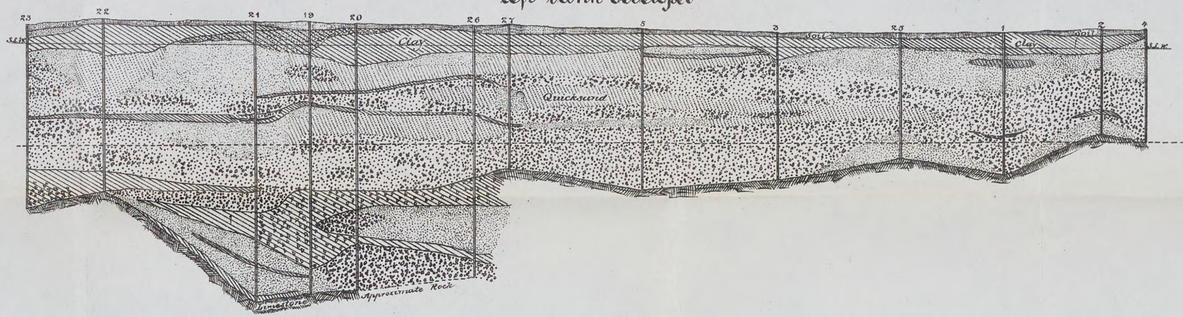
1000 0 1 2 3 4 5 6000 Ft.

Above St. Louis Directrix

Longitudinal Section
Left bank developed

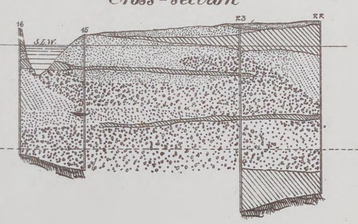


Longitudinal Section
Left bank developed

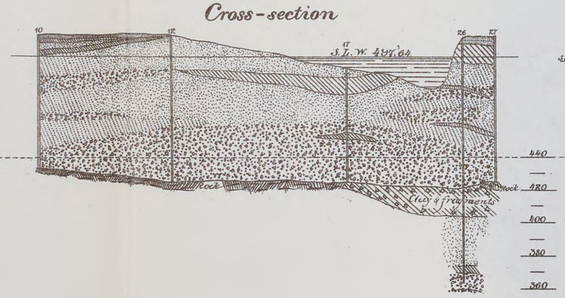


Above St. Louis Directrix

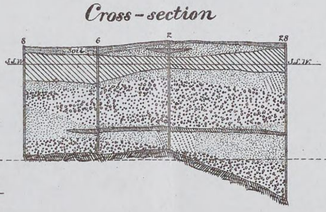
Cross-section



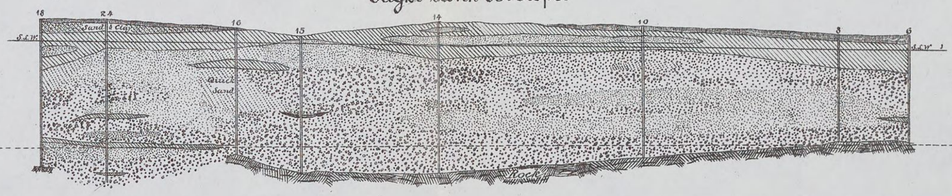
Cross-section



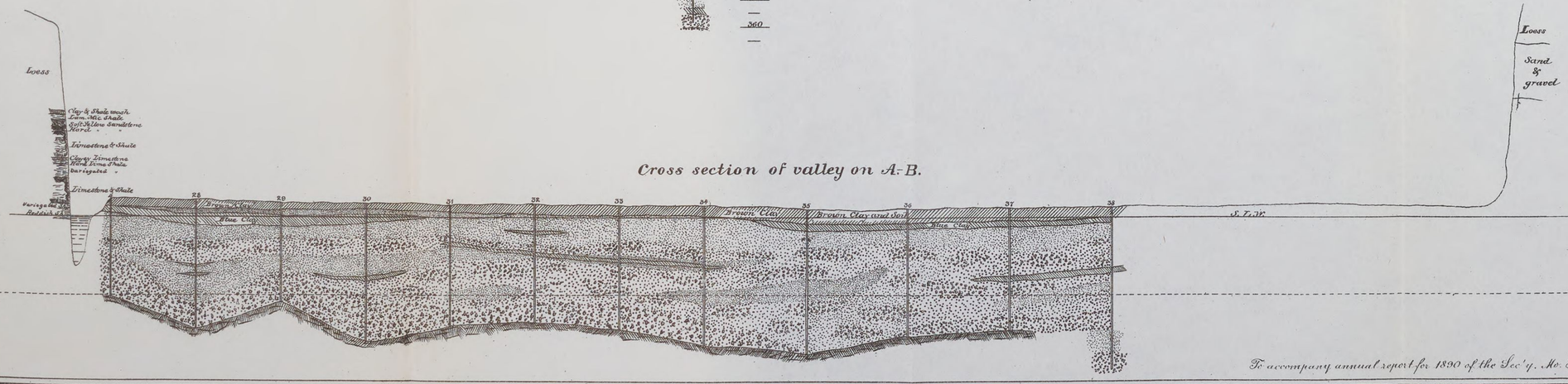
Cross-section



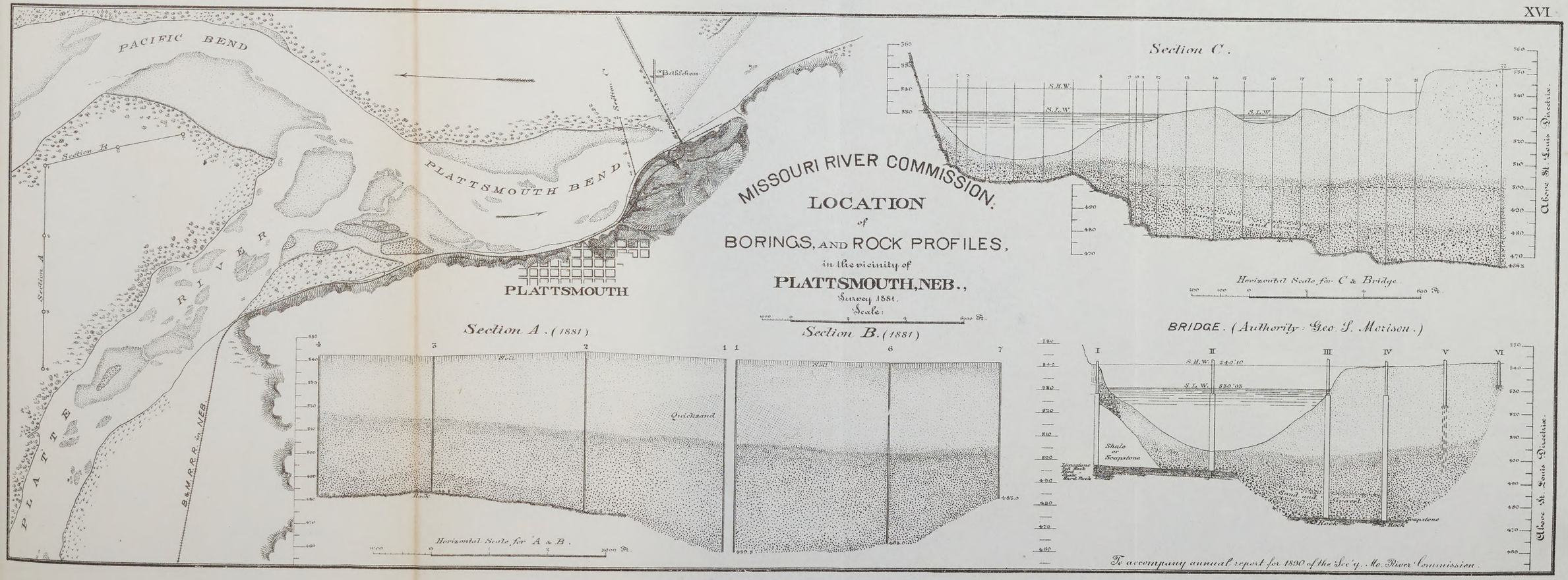
Longitudinal Section
Right bank developed



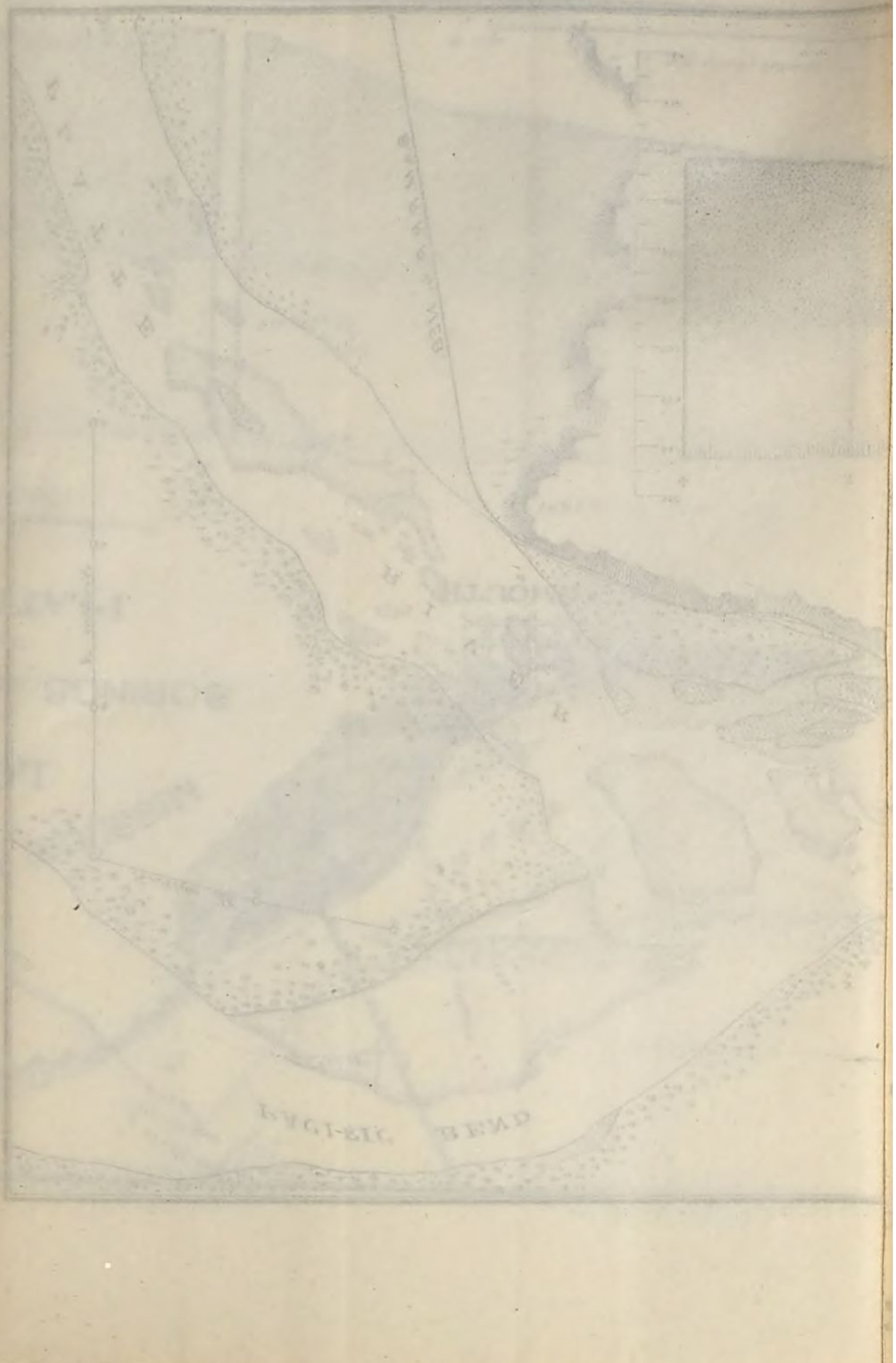
Cross section of valley on A-B.



To accompany annual report for 1890 of the Sec'y. Mo. River Commission.


PACIFIC BEND
PLATTSMOUTH BEND
Bellevue
Section C
Section B
Section A
PLATTE RIVER
B&M R.R.R. in NEB.
PLATTSMOUTH
MISSOURI RIVER COMMISSION.
LOCATION
of
BORINGS, AND ROCK PROFILES,
in the vicinity of
PLATTSMOUTH, NEB.,
Survey 1881.
Scale:
1000 0 1/2 1 2000 Ft.
Section A. (1881)
Quicksand
Rock
Horizontal Scale for A & B.
1000 0 1/2 1 2000 Ft.
Section B. (1881)
Sand
Rock
Section C.
S.H.W.
S.L.W.
Sand and Gravel
Above St. Louis Datum.
Horizontal Scale for C & Bridge
200 100 0 1/2 1 600 Ft.
BRIDGE. (Authority: Geo. S. Morison.)
I II III IV V VI
S.H.W. 340'10
S.L.W. 330'03
Shale or Soapstone
Limestone or Rock
Hard Rock
Sand and Gravel
Above St. Louis Datum.
To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

Eng 90



17

MISSOURI RIVER COMMISSION.

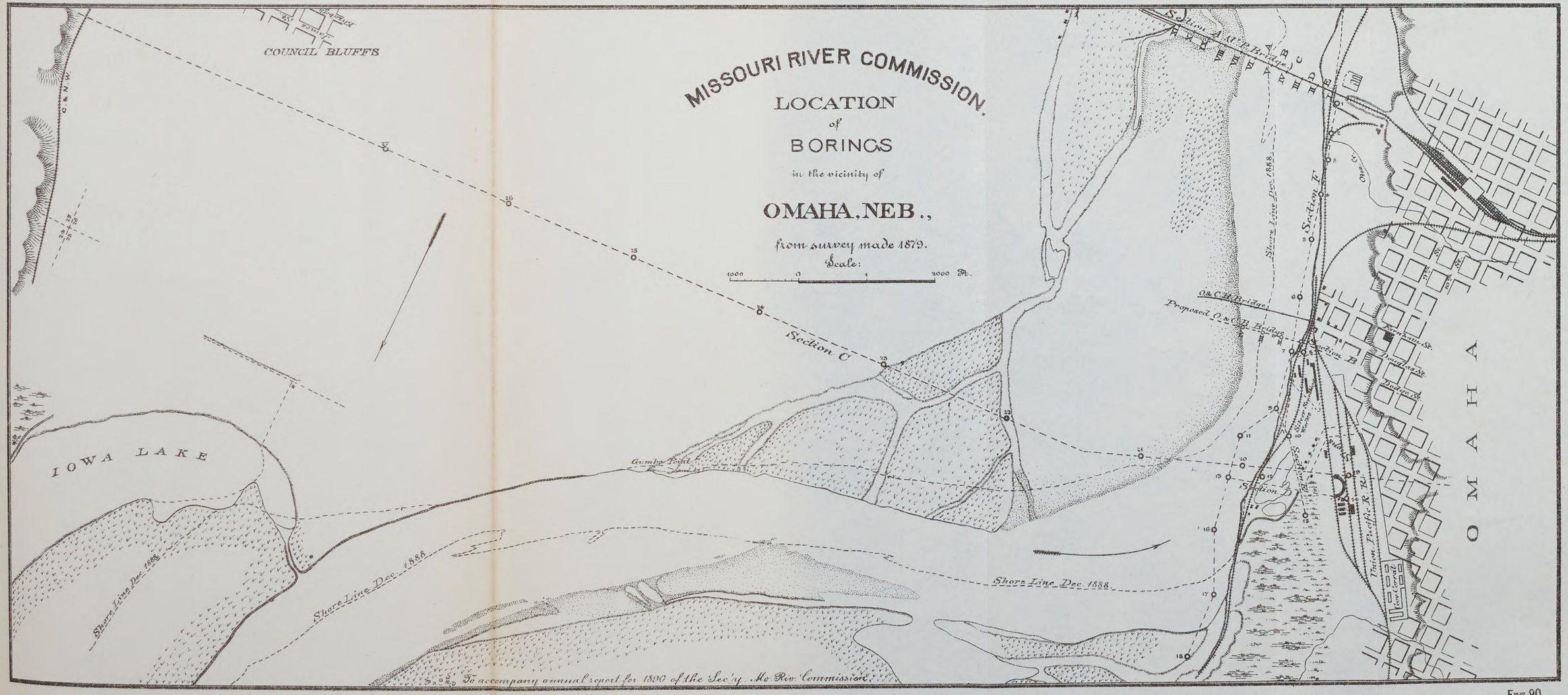
LOCATION of BORINGS

in the vicinity of

OMAHA, NEB.,

from survey made 1879.

Scale: 1000 0 1 2000 ft.



To accompany annual report for 1890 of the Sec'y. Mo. Riv. Commission.

MISSOURI RIVER COMMISSION
LOCATION
of
BORINGS
OMAHA, NEB.

18

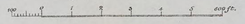
MISSOURI RIVER COMMISSION.

ROCK PROFILES

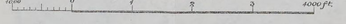
in vicinity of

OMAHA, NEB.

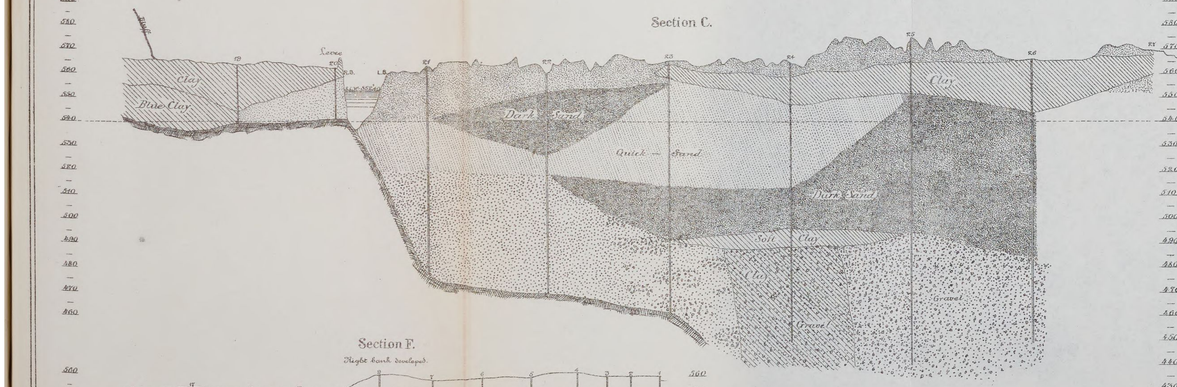
Horizontal Scale:
for sections A & B.



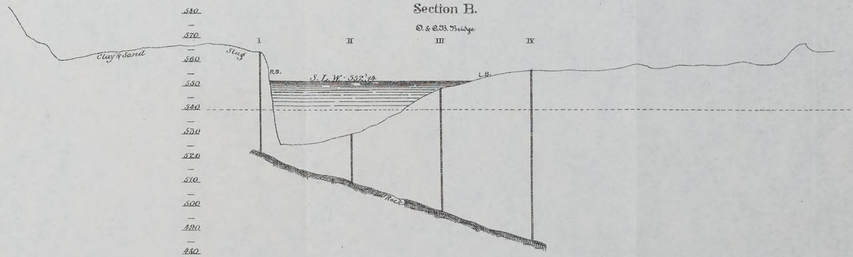
Horizontal Scale:
for sections C. D. E & F.



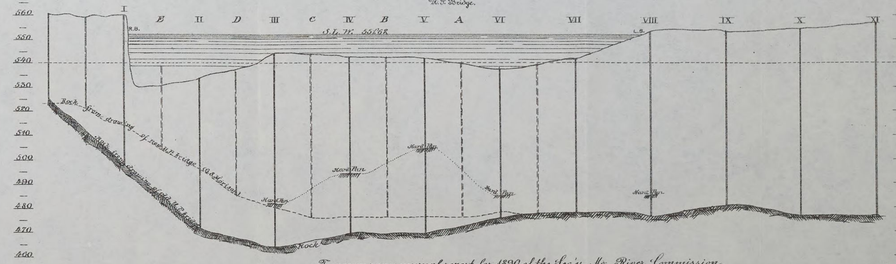
Section C.



Section B.

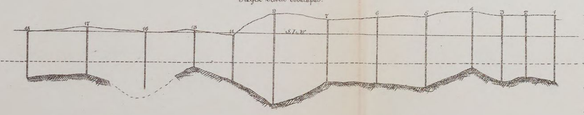


Section A.

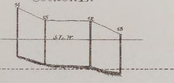


Section F.

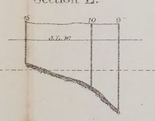
Right bank developed.



Section D.



Section E.



To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

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MISSOURI RIVER COMMISSION

LOCATION

of

BORINGS

in vicinity of

BLAIR, NEB.,

SURVEYED 1883

by Geo. S. Morison

Scale:

1000 0 1 2 3 4 5 6 7 8000 ft.

CUT-OFF 1881.

Soldier R.

Township No 19 North Range

IOWA

NEBRASKA

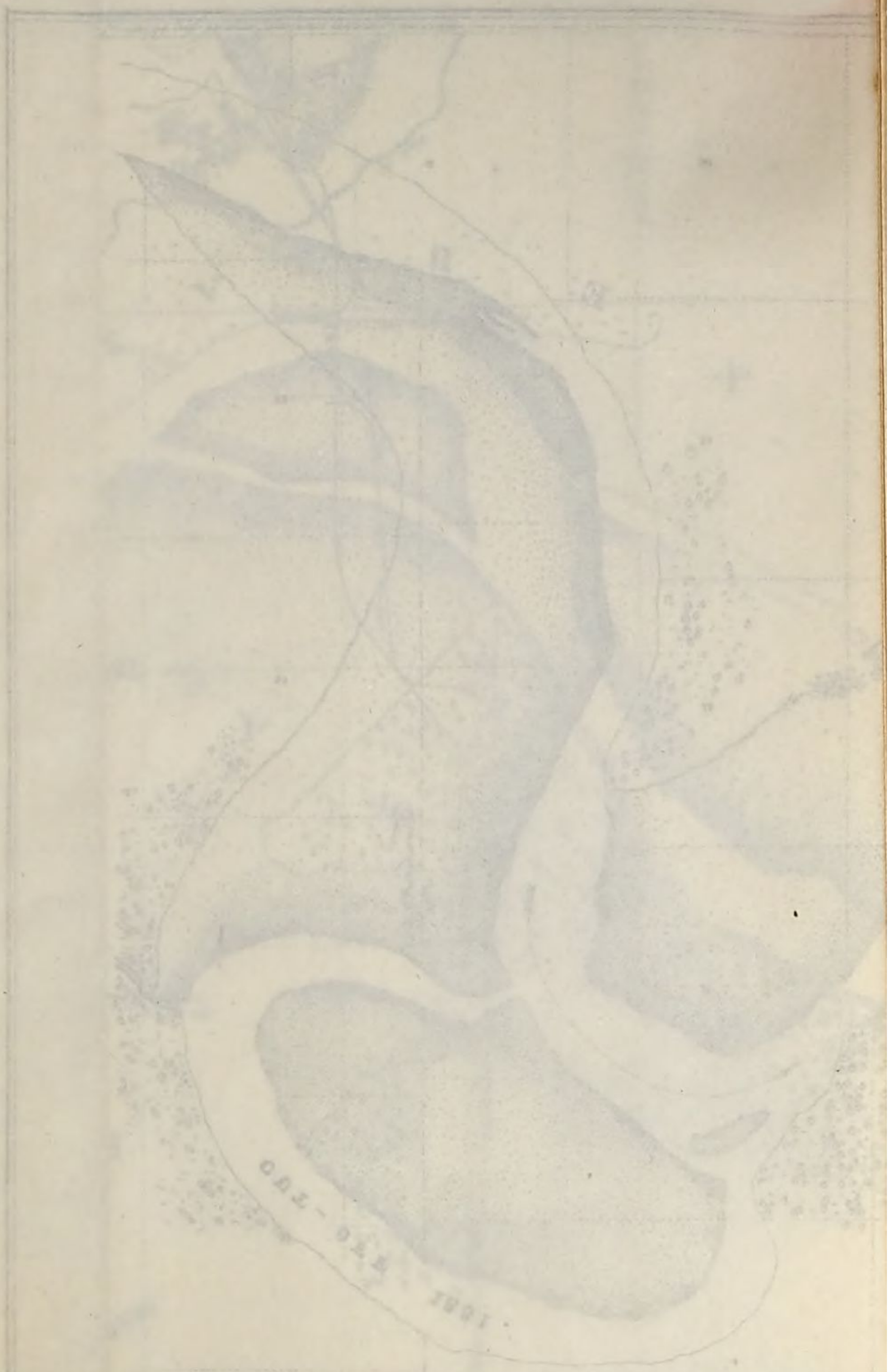
SIOUX CITY & EAGLE R.R.

Range No 45 West of 5th P.M.

Township No 18 North Range

Range No 12 East of 6th P.M.

To accompany annual report for 1890 of the Sec'y. Mo. River Commission.



MISSOURI RIVER COMMISSION.

ROCK PROFILES

and

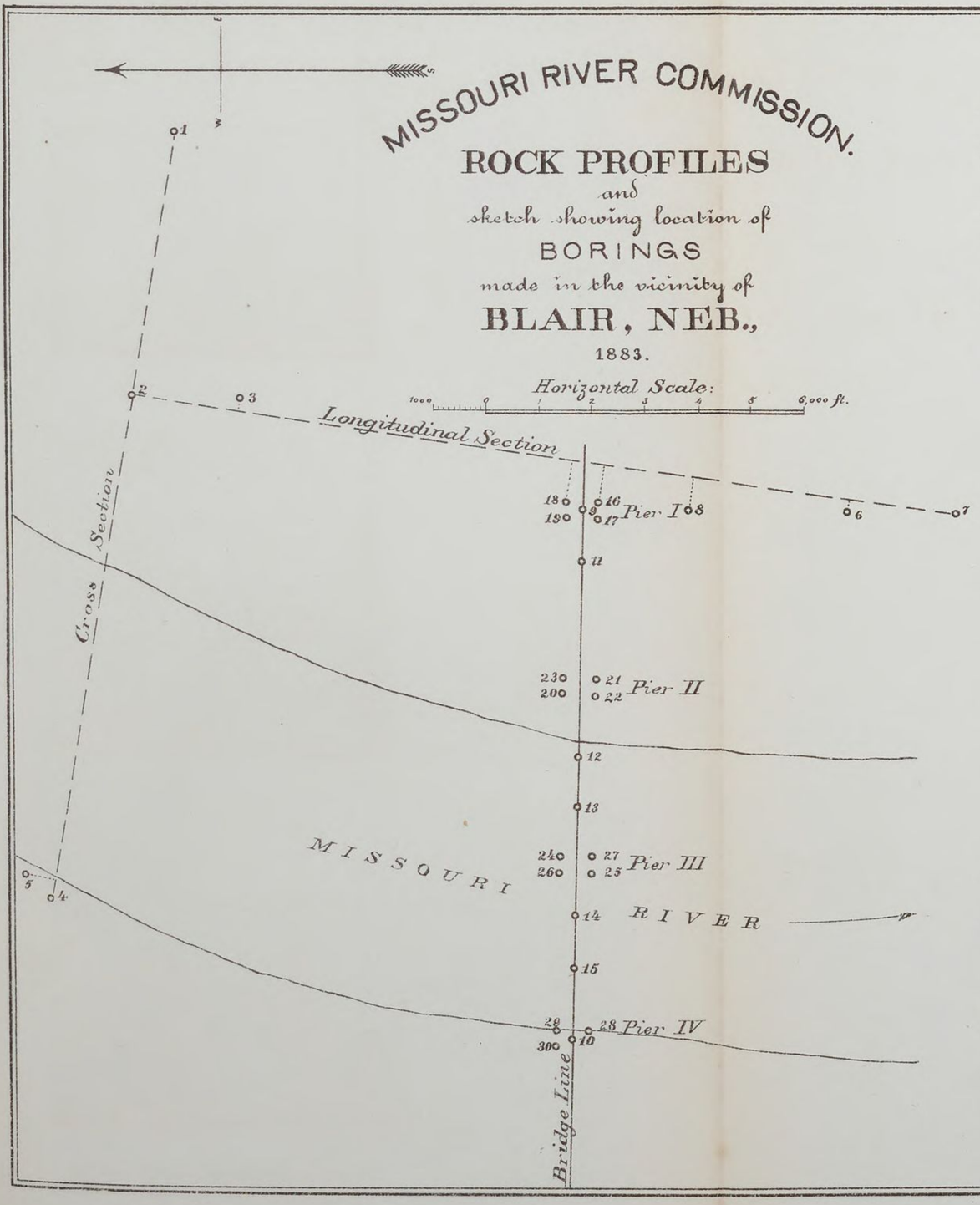
sketch showing location of

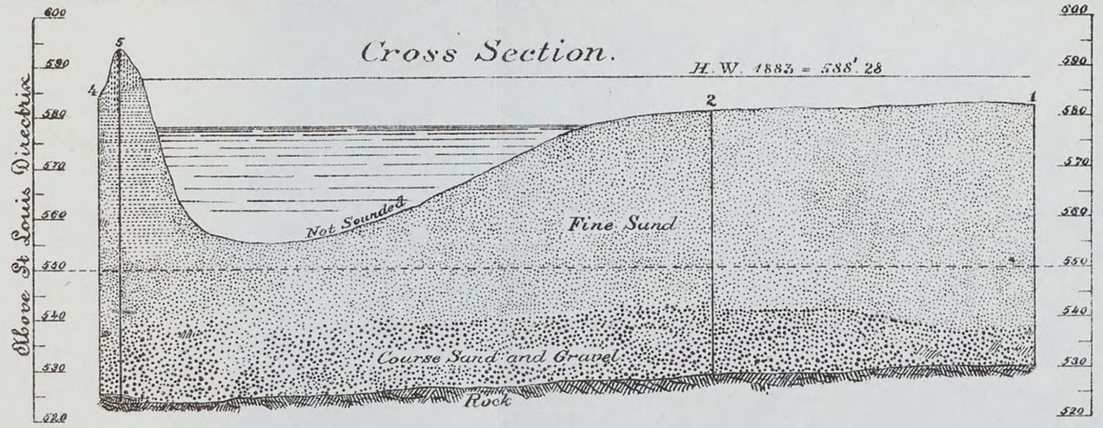
BORINGS

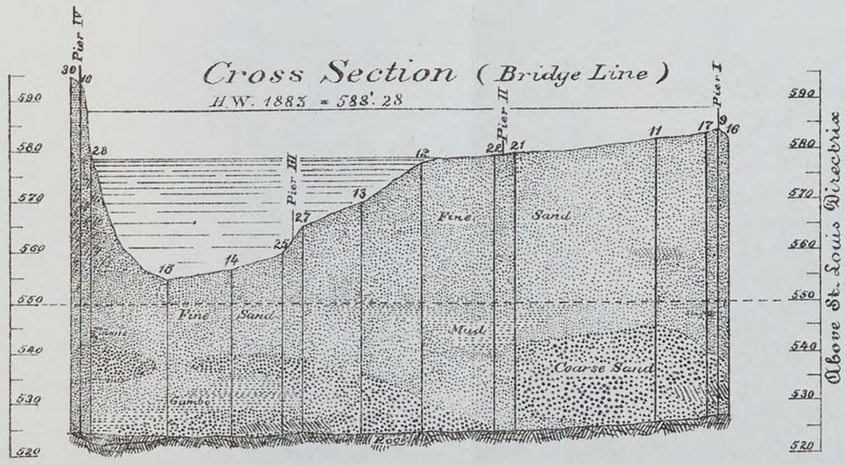
made in the vicinity of

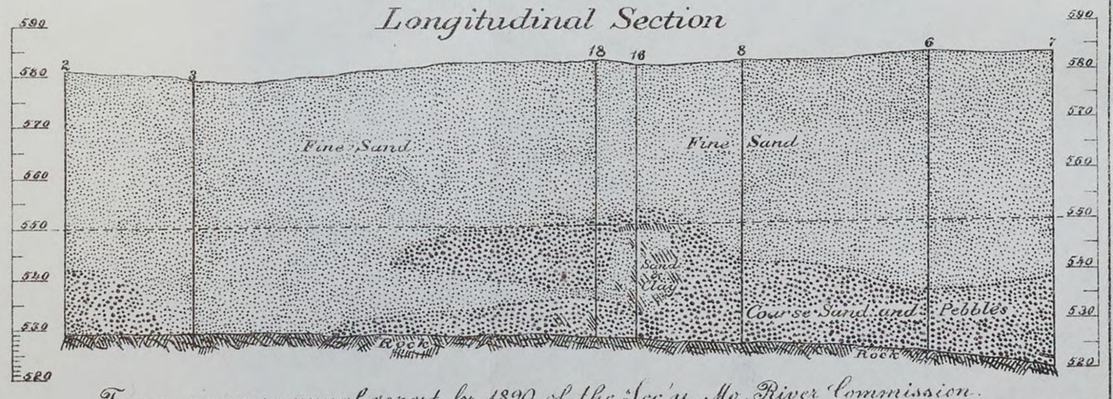
BLAIR, NEB.,

1883.



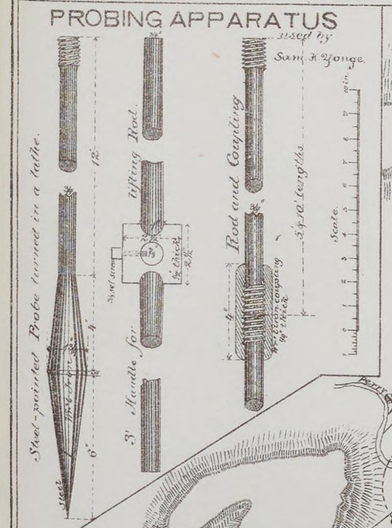


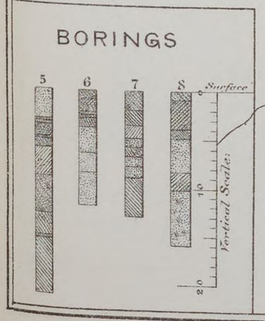


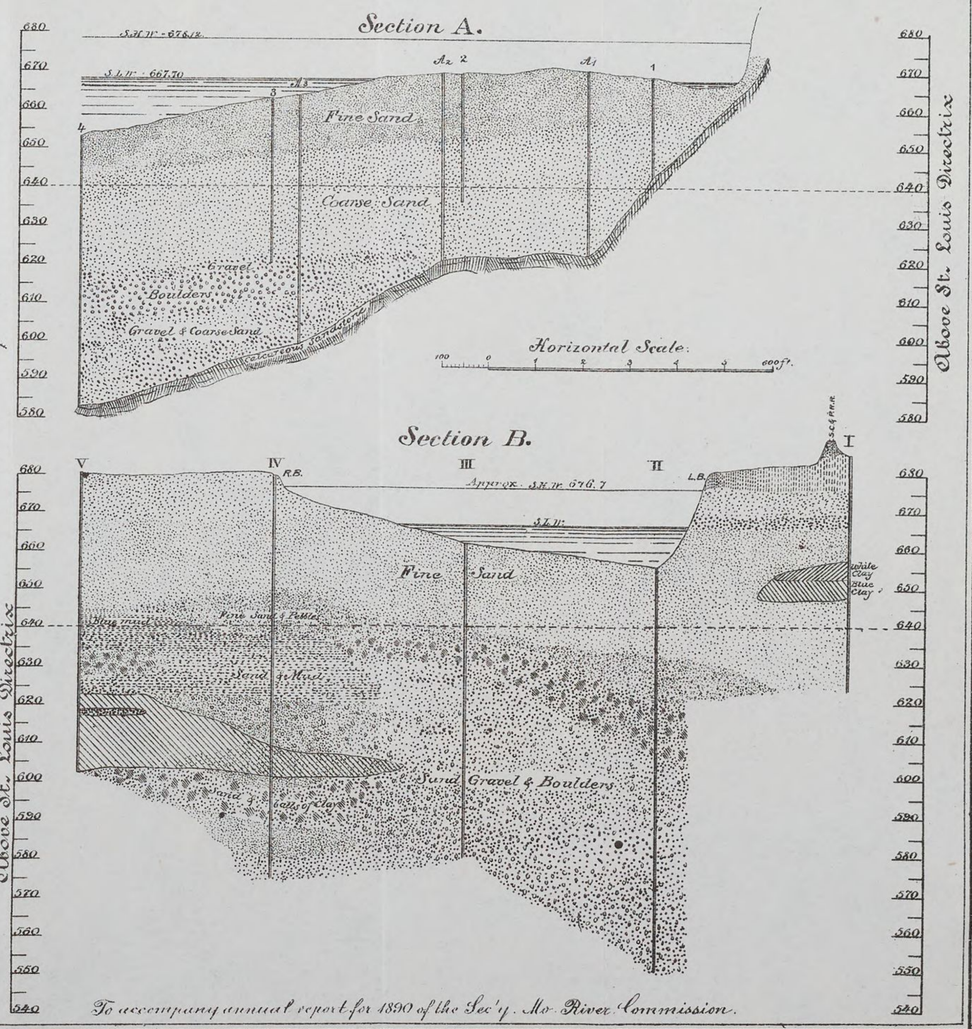


To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

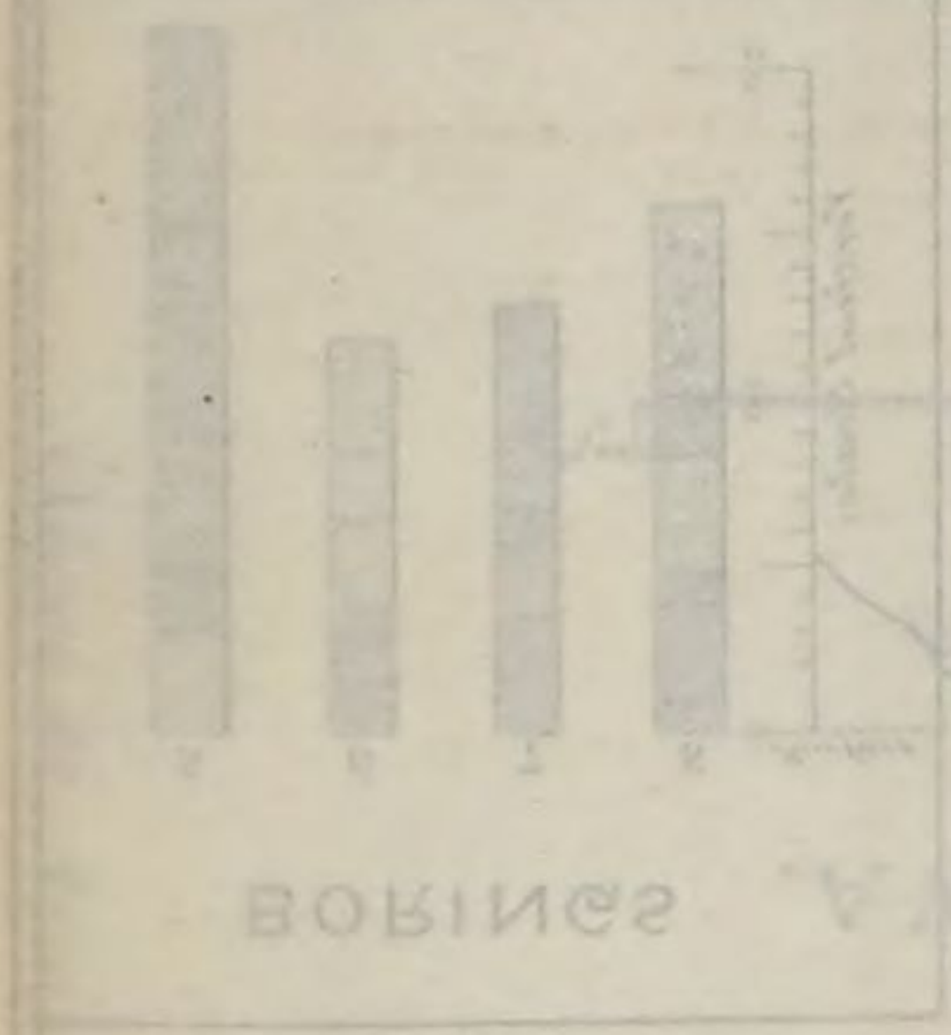
21







To accompany annual report for 1890 of the Sec'y. Mo. River Commission.



BORINGS "A" PILOT



PROBING APPARATUS

MISSOURI RIVER COMMISSION.

LOCATION

of

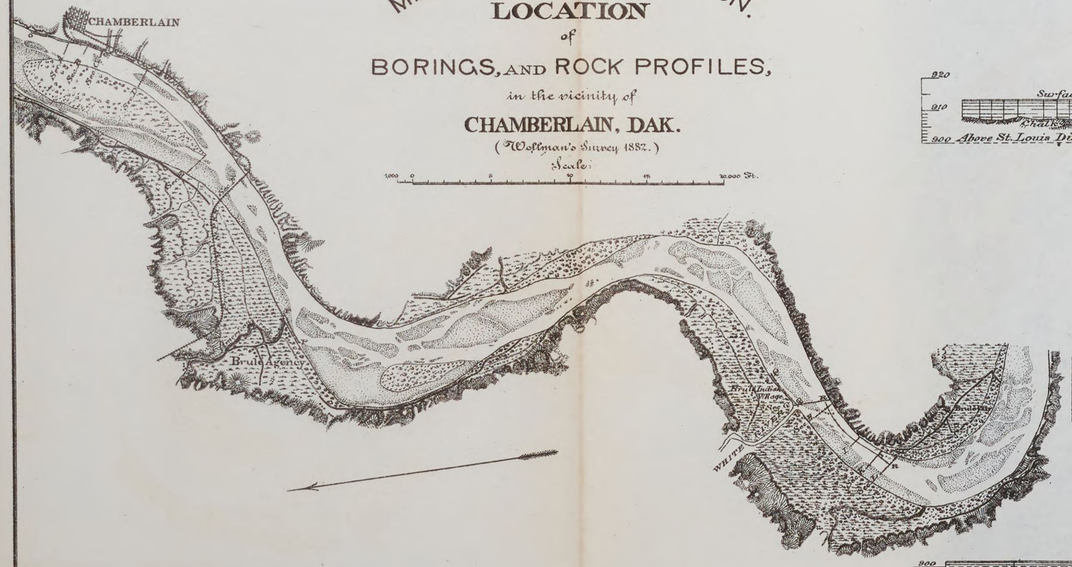
BORINGS, AND ROCK PROFILES,

in the vicinity of

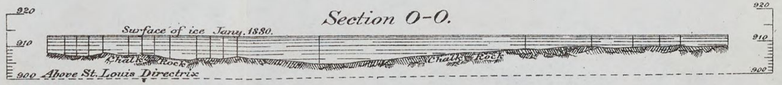
CHAMBERLAIN, DAK.

(Wolfman's Survey 1882.)

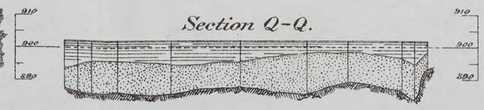
Scale:
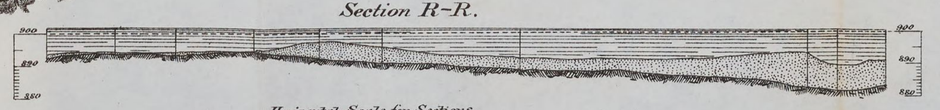


LONGITUDINAL SECTIONS



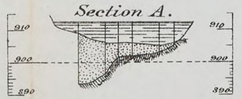






Horizontal Scale for Sections.

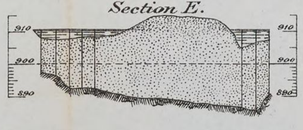
CROSS SECTIONS

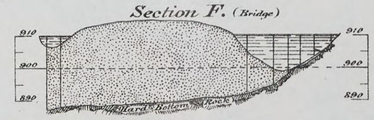










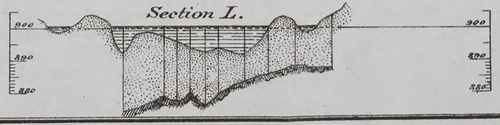












Above St. Louis Directrix.

To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

MISSOURI RIVER COMMISSION.

LOCATION

of

BORINGS, AND ROCK PROFILES.

in the vicinity of

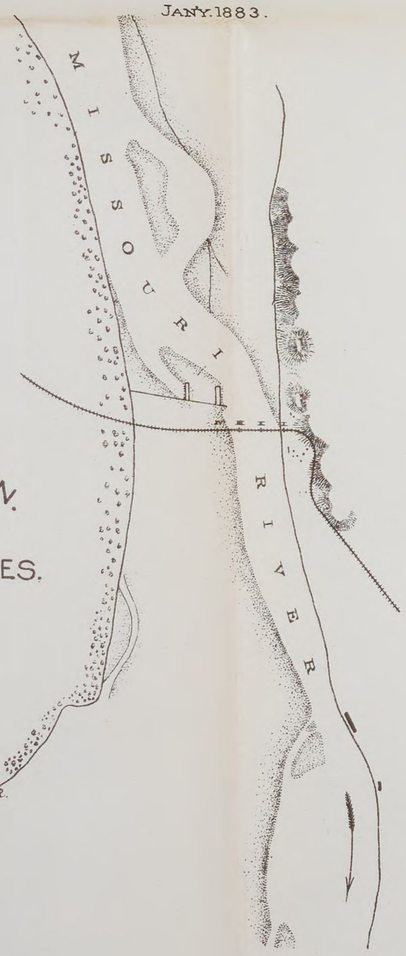
BISMARCK, DAK.,

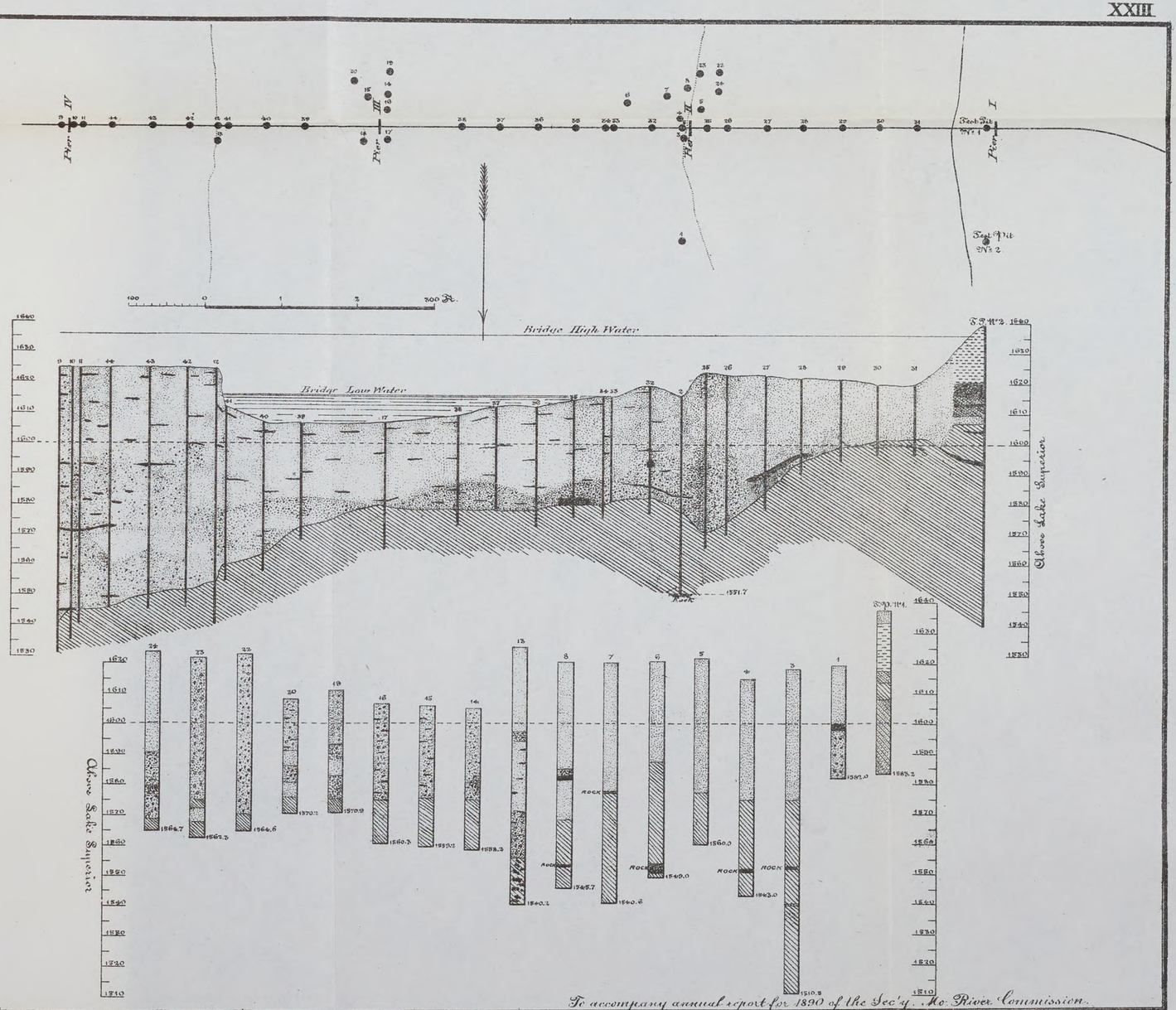
Survey 1883.

Scale:

NOTE:

Authority: George S. Morison's printed report to A. Anderson, Engr. in Chief. N. P. R. R.





To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

MISSOURI RIVER COMMISSION.

LOCATION

of

BORINGS AND ROCK PROFILES.

in the vicinity of

BISMARCK, DAK.,

during 1895.

Scale

NOTE:

MISSOURI RIVER COMMISSION.

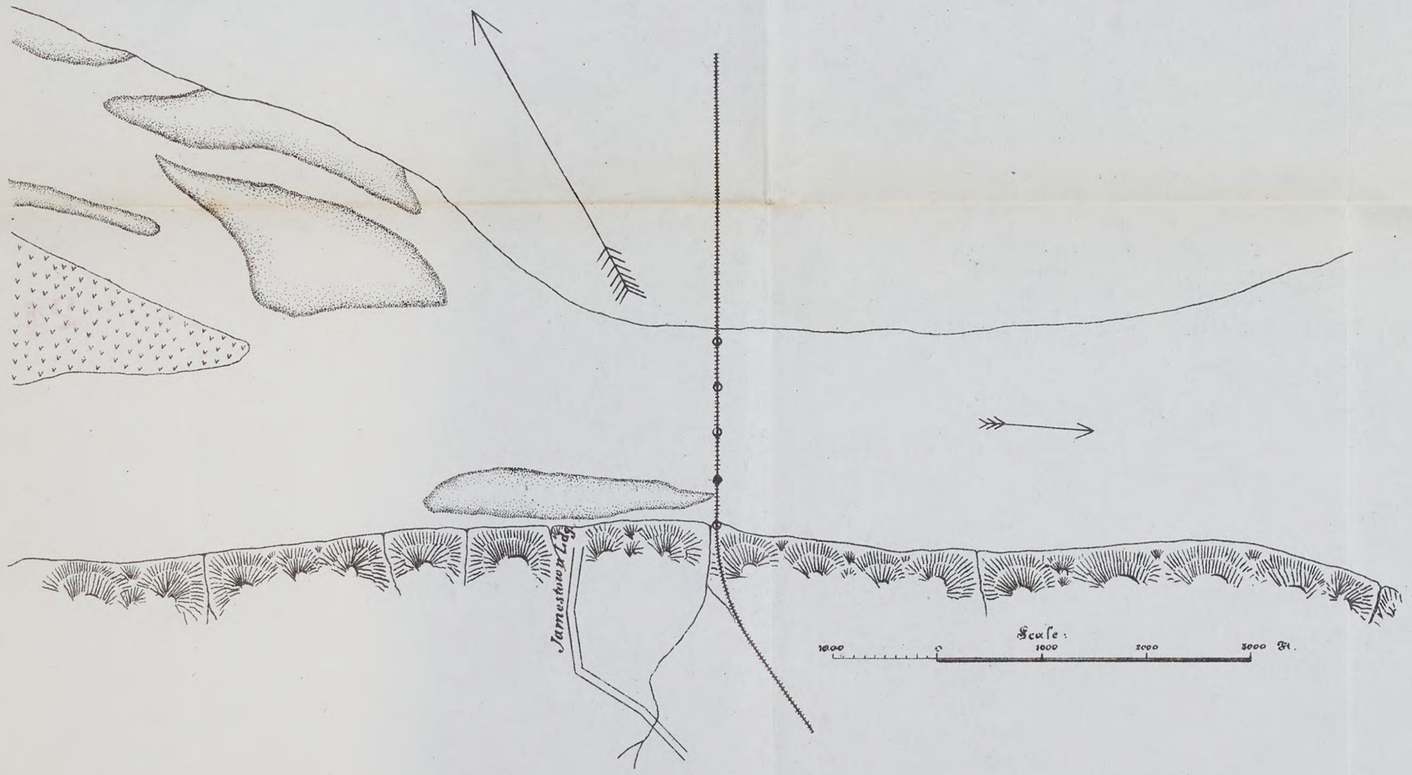
LOCATION

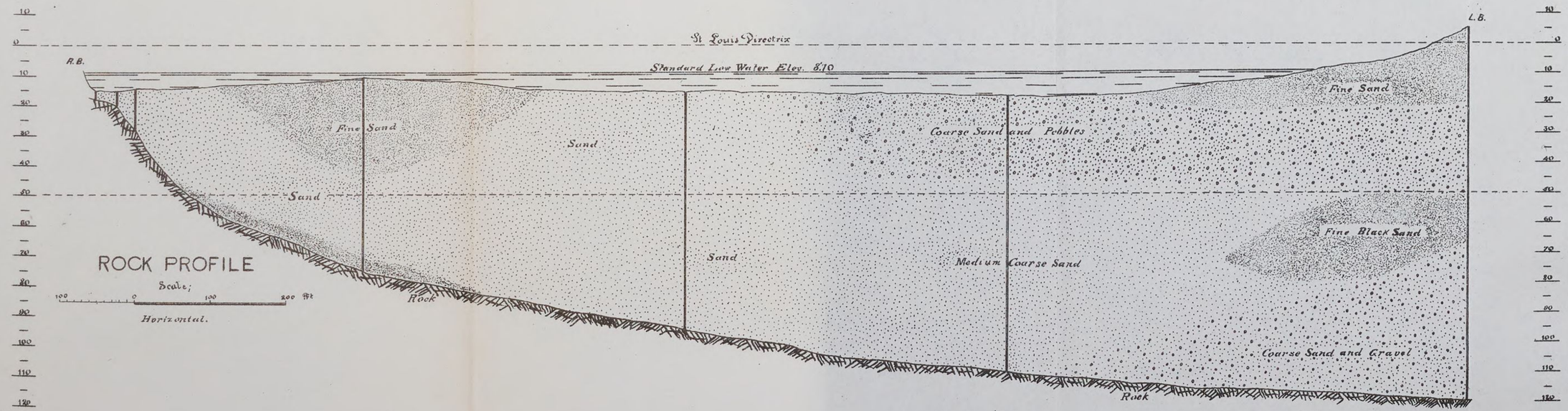
of

BORINGS, AND ROCK PROFILES,

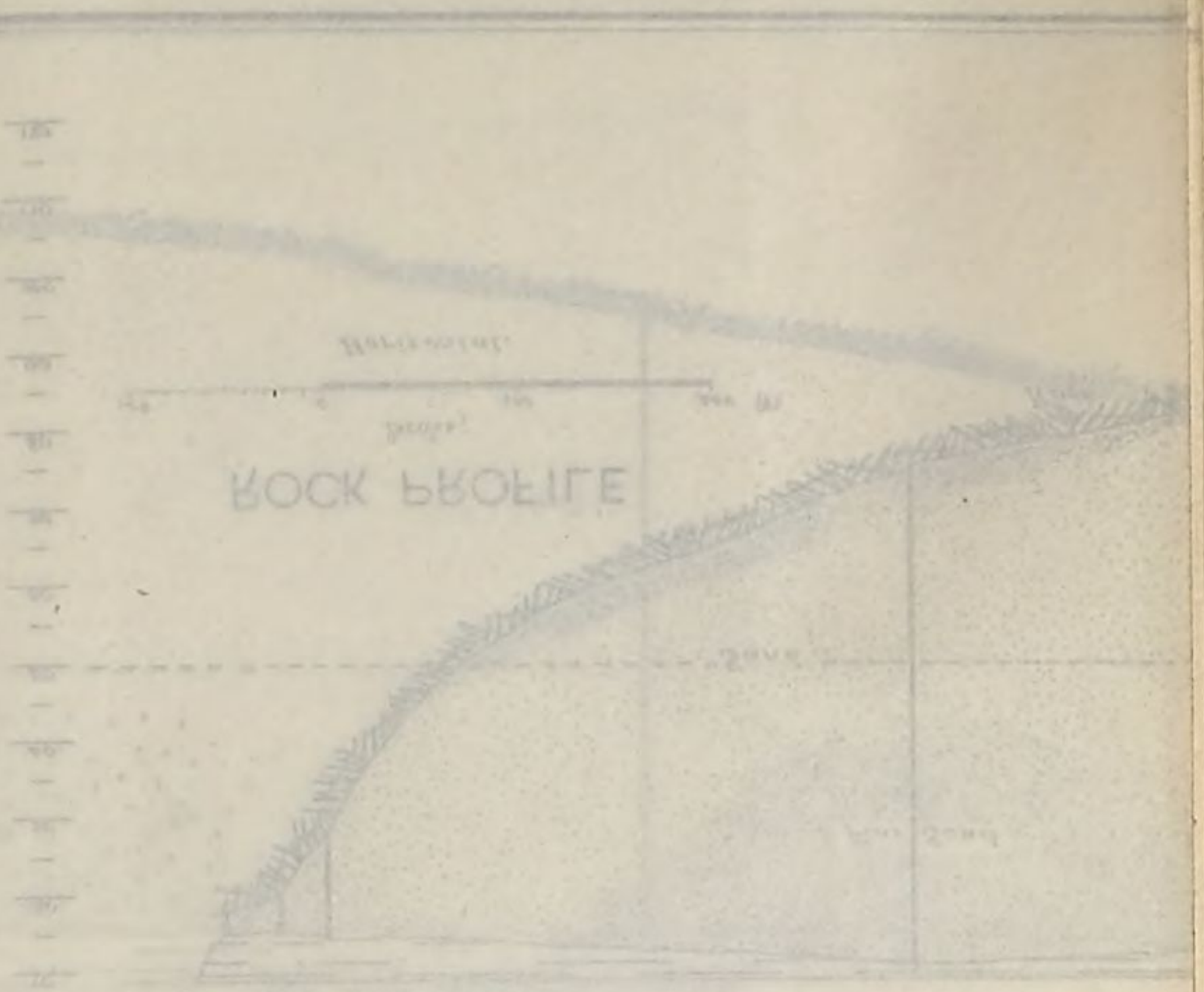
at

BELLEFONTAINE BLUFFS, MO.





To accompany annual report for 1890 of the Sec'y. Mo. River Commission.



BORINGS AND ROCK PROFILES

OF

LOCATION

OF

MISSOURI RIVER COMMISSION

25

MISSOURI RIVER COMMISSION.

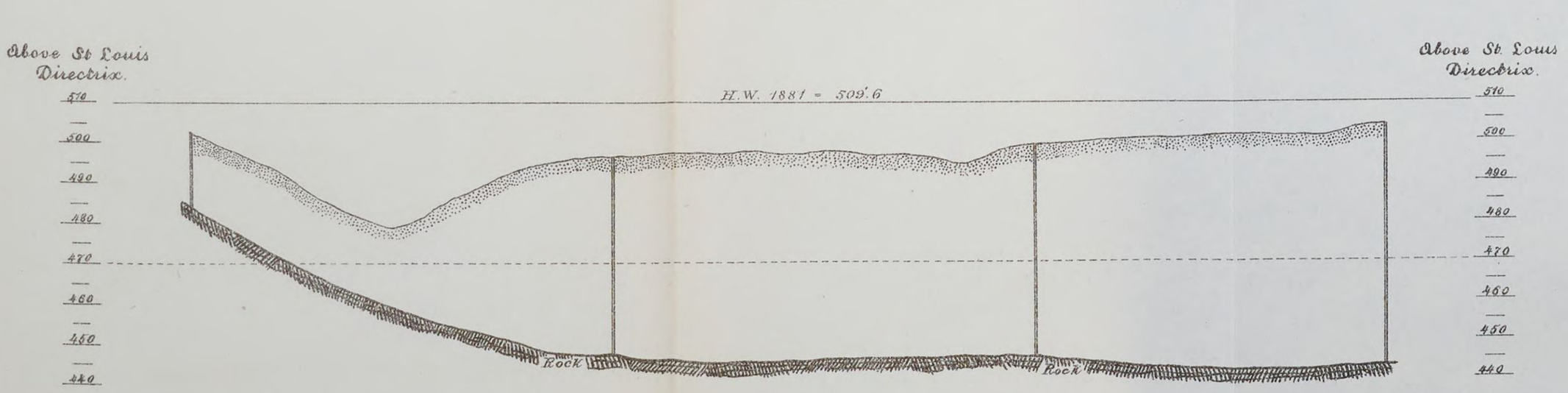
ROCK PROFILES

in vicinity of

NEBRASKA CITY, NEB.

Horizontal Scale:

100 0 100 200 300 400 Ft.



To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

MISSOURI RIVER COMMISSION.

LOCATION

of

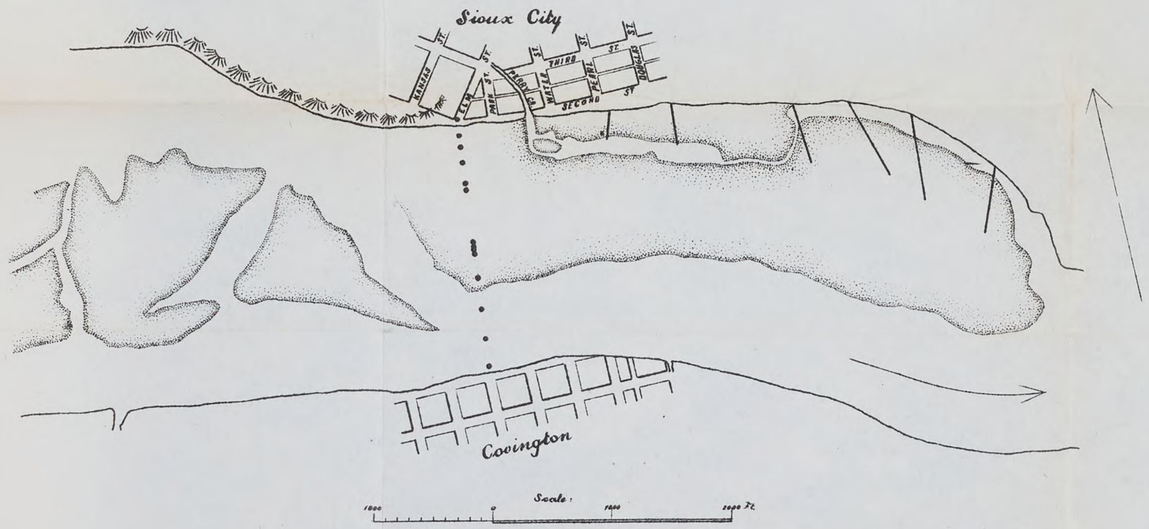
BORINGS, AND ROCK PROFILES,

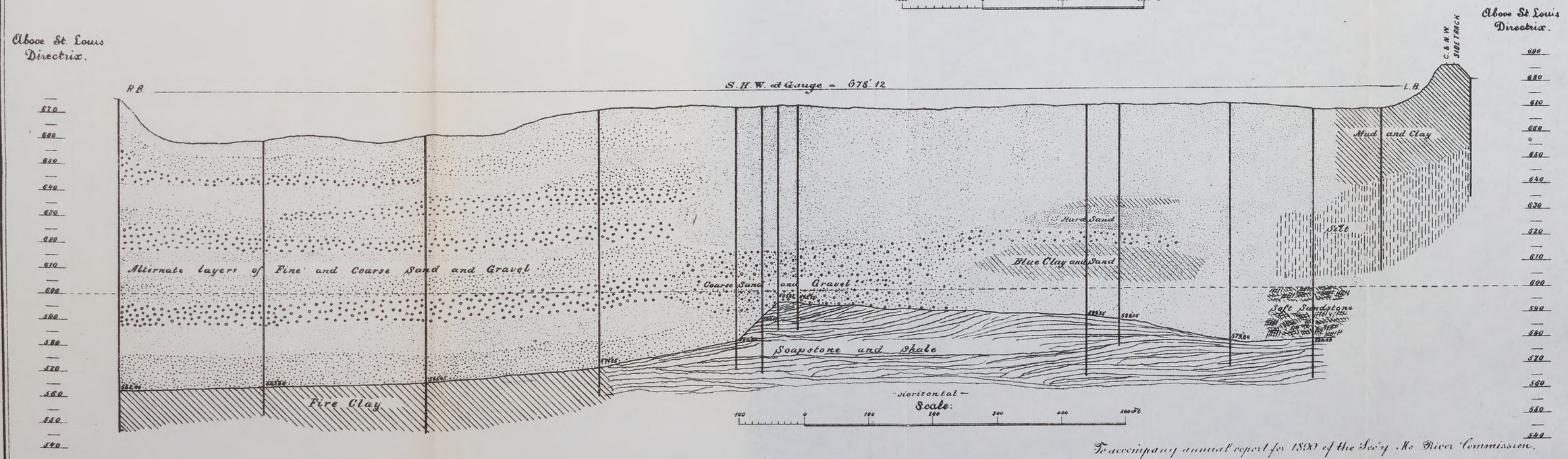
at foot of Elm St.,

SIOUX CITY, IOWA.

1889,

Survey by Sioux Cy. Bridge Co.





To accompany annual report for 1890 of the Sec'y. Mo River Commission.

MISSOURI RIVER COMMISSION.

LOCATION

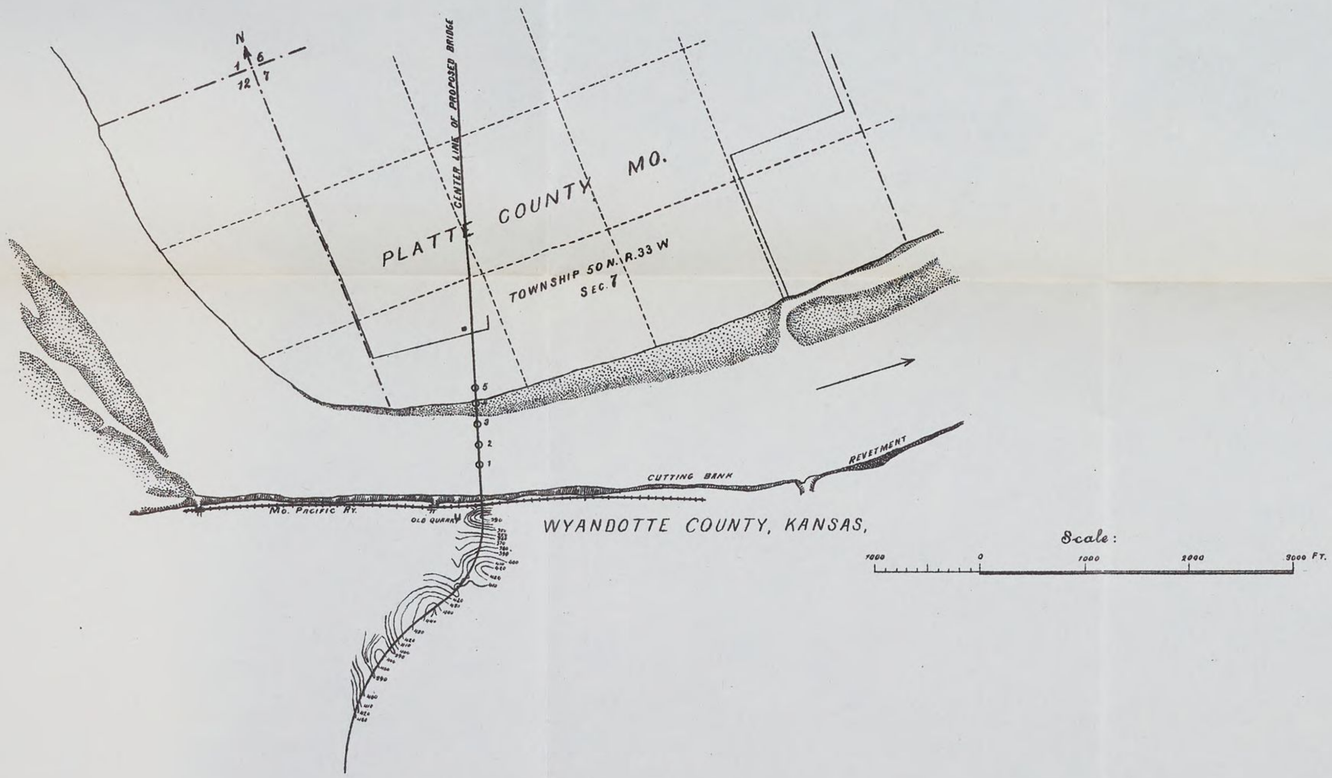
of

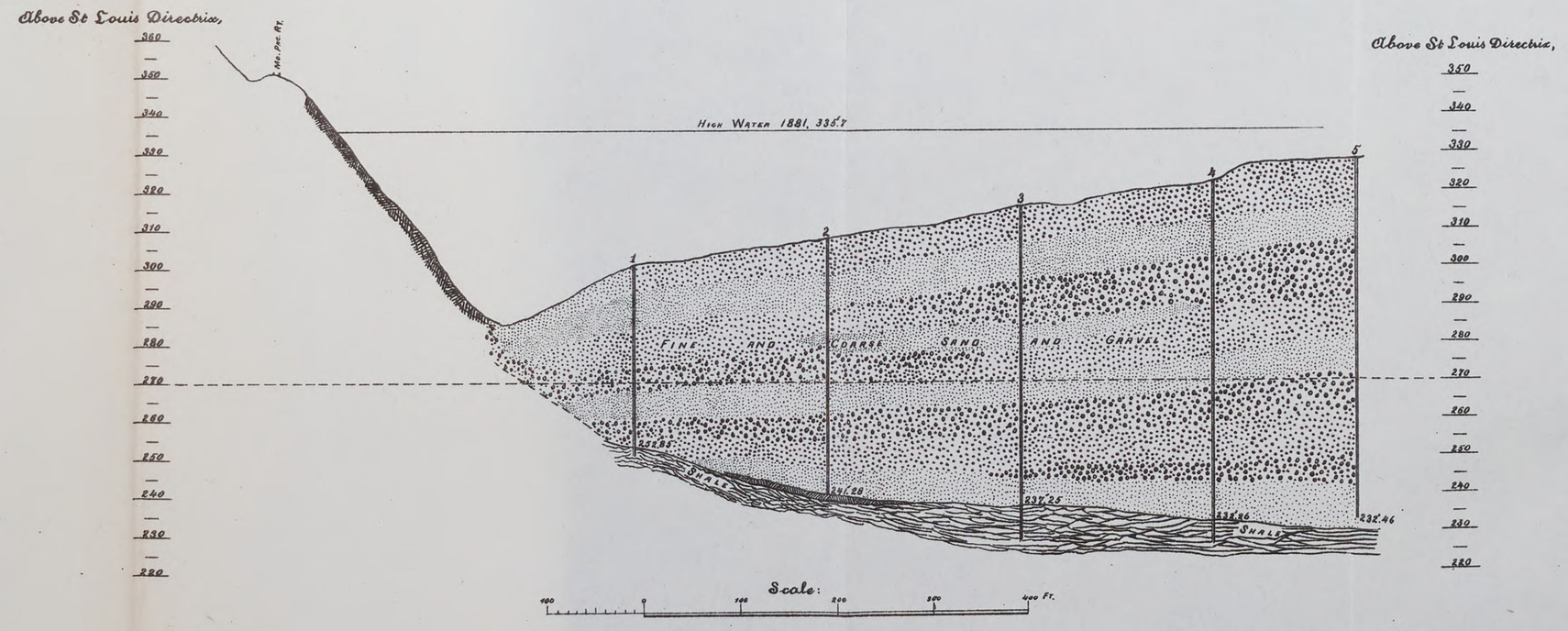
BORINGS, AND ROCK PROFILES,

in the vicinity of

QUINDARO, KAN.,

from surveys made by J. A. L. Waddell - August, 1889.





To accompany annual report for 1890 of the Sec'y. Mo. River Commission.

since the above date. Captain Bingham's preliminary remarks on conventional signs, elevations, and authorities apply also to this report.

Very respectfully, your obedient servant.

JAMES C. SANFORD,
First Lieutenant of Engineers,
Secretary Missouri River Commission.

Lieut.-Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

Index table to additional borings.

Location.	From mouth of river.	No. of plate.	Date of making borings.	Total distance bored.	No. of borings.	Deepest boro hole.	Lowest elevation reached, referred to St. L. Directrix.	Character of rock.	Remarks.
	Miles.			*Feet.*		*Feet.*	*Feet.*		
Bellefontaine Bluffs, Mo.	7	XXIV	1889	381	7	123.5	119.0	Limestone.	By Geo. S. Morison.
Nebraska City, Nebr.	608.2	XXV	1889	181	4	60	443	....do	By J. A. L. Waddell.
Sioux City, Iowa	802.8	XXVI	1889	1,345	14	129	546	Shale	Do.
Quindaro, Kan...	394.9	XXVII	1889	410	6	96	226.5	....do	Do.

BELLEFONTAINE BLUFFS, MISSOURI.

Plate XXIV: This plate is a reduction of drawings furnished by the courtesy of Mr. George S. Morison, consulting engineer, and Mr. B. L. Crosby, resident engineer of the St. Louis, Keokuk and Northwestern Railroad.

The eleavtion to the successive layers of materials encountered are given with considerable minuteness, and the drawings embody all the information that has been gained.

NEBRASKA CITY, NEBRASKA.

Plate XXV: This plate is a reduction from drawings furnished to the city of Nebraska City for a wagon bridge by Mr. J. A. L. Waddell, consulting engineer, and embodies all the information that has been obtained.

SIOUX CITY, IOWA.

Plate XXVI: This plate is a reduction of drawings furnished by Mr. J. A. L. Waddell, consulting engineer, for a bridge over the Missouri River at the foot of Elm street.

The line on which the borings were taken is but slightly different from that designated as section A, Plate XXJ. The rock is described as shale and soap-stone.

QUINDARO, KANSAS.

Plate XXVII: This plate is a reduction from drawings made by Mr. J. A. L. Waddell, consulting engineer, presenting a design for a proposed bridge at this point, 8.6 miles above Kansas City. All the information attainable is embodied in the drawings. The bridge is not yet under construction.

A 3.

Dates of ice closings and openings on the Missouri River.

[Continued from page 2326, Report of Chief of Engineers, U. S. Army, for 1888.]

Locality.	1887–'88.		1888–'89.		1889–'90.	
	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.
Bismarck	.....	Apr. 9	Nov. 6	Mar. 24	Nov. 15	Apr. 6
Sioux City	Nov. 27	Apr. 2	Jan. 20	Mar. 5	Nov. 29 Jan. 1	Dec. 4 Mar. 20
Blair	.....	Mar. 19	Jan. 1	Mar. 6	Nov. 28 Dec. 31 Feb. 21	Dec. 1 Feb. 13 Mar. 18
Omaha	Dec. 21	Mar. 15	Dec. 21 Dec. 29	Dec. 23 Mar. 4	Nov. 28 Jan. 3 Feb. 25	Dec. 8 Feb. 15 Mar. 19
Plattsmouth	Nov. 27	Mar. 14	Feb. 21	Mar. 3	Nov. 29 Jan. 7 Feb. 28	Dec. 1 Feb. 7 Mar. 16
Nebraska City	Nov. 27 Dec. 20	Dec. 3 Mar. 16	Jan. 3	Mar. 4	Nov. 29 Jan. 3 Feb. 20	Nov. 30 Feb. 10 Mar. 16
Brownville	Nov. 27 Dec. 21	Nov. 30 Feb. 23	Dec. 28 Feb. 13	Dec. 29 Feb. 15	Nov. 29 Jan. 13 Feb. 28	Dec. 1 Feb. 10 Mar. 16
Rulo	Dec. 21	Feb. 23	Dec. 28 Feb. 24	Jan. 21 Mar. 1	Jan. 5 Feb. 20	Feb. 4 Mar. 17
White Cloud	Nov. 28 Dec. 21	Dec. 1 Feb. 22	Dec. 28 Jan. 27 Feb. 23	Jan. 17 Feb. 4 Mar. 1	Jan. 3	Jan. 9
St. Joseph pump house	.....	.....	Dec. 28 Feb. 17	Mar. 1	Jan. 13 Feb. 26	Feb. 4 Mar. 14
St. Joseph Bridge	.....	.....	.....	.....	Jan. 13 Feb. 20	Feb. 3 Mar. 15
Atchison	Dec. 18	Feb. 20	Open all winter.....		Jan. 7 Feb. 28	Feb. 4 Mar. 13
Fort Leavenworth Bridge	Dec. 21	Feb. 19	Feb. 24	Feb. 28	Jan. 13 Feb. 22 Feb. 26	Jan. 31 Feb. 25 Mar. 12
Leavenworth	Dec. 21	Feb. 20	Feb. 24	Mar. 1	.....	.....
Kansas City	Dec. 21	Feb. 17	Jan. 27 Feb. 20	Feb. 3 Mar. 1	Jan. 13 Feb. 20	Jan. 27 Mar. 9
Randolph	.....	.....			Jan. 21 Feb. 28	Jan. 30 Mar. 10
Sibley	.....	.....			Open all winter.	
Lexington	Dec. 29	Feb. 18	Open all winter.		Jan. 22 Mar. 4	Jan. 31 Mar 11
Waverly	Dec. 24	Feb. 17			Jan. 20 Feb. 28	Jan. 30 Mar. 10
De Witt	Dec. 21	Feb. 18	Feb. 25	Mar. 1	Jan. 19 Feb. 27	Jan. 29 Mar. 10
Glasgow	Dec. 22	Feb. 17	Open all winter....		Open all winter.	
Boonville	Dec. 23	Feb. 18				
Jefferson City	Dec. 28 Jan. 16	Jan. 6 Feb. 4	Feb. 24	Mar. 1	Open all winter.	
Hermann	Dec. 29 Jan. 11 Feb. 10	Jan. 7 Feb. 5 Feb. 19	Open all winter...		Open all winter.	
St. Charles	Dec. 30	Jan. 8				
St. Louis	Dec. 21	Feb. 2				

A 4.

Descriptions and elevations of bench-marks on the Missouri River, referred to St. Louis City directrix, May, 1890.

[List of Bench-Marks No. 1 was issued 1881–'82, and was followed by List No. 2, published in Appendix VV of the Annual Report of the Chief of Engineers for 1888. This is List No. 3, and comprises all of the new bench-marks at present located by survey connections not published in List No. 2. It is corrected by all data on file up to date. The elevations were determined by wye levels, and were run between dates October 16, 1888, and March 12, 1889. The new bench-marks are placed on lines generally straight across the valley, these lines being about 5 miles apart. Their designations are in the form of a fraction, the numerator being the number of the line reckoning from the mouth up; the denominator being the number of the bench-mark in that line reckoning from the right bank. All elevations refer to the St. Louis City directrix, which is 433.97 feet above the Cairo datum and 412.71 feet above the Mississippi River Commission 1881 determination of mean Gulf tide at Biloxi, Miss.]

No.	Description.	Elevation.	Above the mouth.
		Feet.	*Miles.*
$\frac{1}{1}$ Mouth Missouri River.	Is about 2½ miles below site of old Fort Bellefontaine, at the foot of the bluff, at east fence of the Columbia Bottom rock road where it turns east across the bottom	12.462	.....
$\frac{1}{2}$	Is near the middle of Columbia Bottom, at mouth of Missouri River, 6,347 feet, N. 76° E. (mag.) from $\frac{1}{1}$ on east side of young orchard belonging to Philip Freese, about 400 feet north of his dwelling-house	4.694	.....
$\frac{2}{1}$ Fort Bellefontaine.	Is at foot of bluff, 150 feet east of Cold Water Creek, near site of old Fort Bellefontaine	16.370	5.9
$\frac{2}{2}$	Is between the fences which run east and west between the farms of Major Strong and Mr. Furgeson, and is about 3,865 feet N. 86° W. (mag.) from school-house shown on map	10.908	.....
$\frac{3}{1}$ Jamestown Landing.	Is about 2 miles above Jamestown Landing, at foot of bluff, 75 feet west of small stream on land of Wm. Berger, 520 feet from the river	27.525	9.4
$\frac{3}{2}$	Is at south fence of door-yard of Joseph Fister, 170 feet south of the "New Alton road," about 400 feet east of south end of Smelser's Lake	12.051	.....
$\frac{3}{3}$	Is at south fence of road running nearly east and west along the bank of slough forming Dresser Island, 3,975 feet N. 7° 5′ E. (mag.) from $\frac{3}{2}$, and 600 or 700 feet east of north end of Smelser's Lake	4.457	.....
$\frac{4}{1}$ Hall's Ferry.	Is in southwest corner of Ferd. Wisner's door-yard, at Hall's Ferry, Mo., about 500 feet below the old stone ferry-house	26.845	15.3
$\frac{4}{2}$	Opposite Hall's Ferry, at south fence of "Alton road," 1,813 feet S. 47° W. (mag.) of the angle in road shown on the map	21.706	.....
Charbondier Point.	High-water mark of 1883, on southwest corner of L. C. Knapp's dwelling-house	25.193	.....
$\frac{5}{1}$	Is at south fence of door-yard of L. C. Knapp, at angle of Charbonnier road (shown on map), about one-quarter of a mile above Charbonnier Point	21.792	19.8
$\frac{5}{2}$	Is at south fence of county road, the general direction of which is about N. 50° E. (mag.), in northwest corner of Wm. Kilpatrick's farm, and 9,545 feet N. 41° W. (mag.) from $\frac{5}{1}$	19 101	.....
$\frac{6}{1}$ St. Charles.	Opposite St. Charles, in southwest corner of door-yard of Lewis Yoste, at north side of St. Charles rock road at foot of the bluff	66.416	25.3
$\frac{6}{2}$	In St. Charles, in southeast corner of a block, 95 feet from the river and 1,292 feet above the west pier of the St. Charles Railroad bridge	31.567	.....
$\frac{7}{1}$ Creve Cœur Lake.	Is at foot of bluff near northeastern end of Creve Cœur Lake, about 1,200 feet below where shore of lake curves away from the bluff	30,960	.....
$\frac{7}{2}$	Is about 2,500 feet east of north fron the lower or northern end of Creve Cœur Lake, on south side of wagon road running east and west 607 feet north of track and about one-quarter of a mile S. 83° W. (mag.) from water-tank St. Louis, Kansas City and Colorado Railroad	35.926	.....
$\frac{8}{1}$	Is about 4 miles above St. Charles Railroad bridge, at north right-of-way fence Cleveland, St. Louis and Kansas City Railroad, 60 feet east of small creek; in southwest corner of W. Dukmeyer's land	33.232	32.0
$\frac{8}{1}$ Valley Forge Station.	At Valley Forge Station, St. Louis, Kansas City and Colorado Railroad, at foot of the bluff, 153 feet west of road running from the bottom up into the hills	37.122	35.0
$\frac{8}{2}$	Is at the foot of bluff at the mouth of Ducket Creek Valley, 50 feet west of Ducket Branch road, and about the same distance north of track of Cleveland, St. Louis and Kansas City Railroad	41.861	.....
$\frac{8}{1}$ Gumbo P. O.	Is in the northeast corner of cemetery at Gumbo Station, St. Louis, Kansas City and Colorado Railroad	50.154	40.7

Descriptions and elevations of bench-marks on the Missouri River, etc.—Continued.

No.	Description.	Elevation.	Above the mouth.
		Feet.	*Miles.*
9/2	Is at south line of Olive Street road, 235 feet east of point where Gumbo Station road meets the Olive Street road	41.719	
9/3	Opposite Bon Homme Island; is 50 feet north of center line of Cleveland, St. Louis and Kansas City Railroad; 300 feet west of point where the foot of bluff wagon-road leaves the bottom and enters the hills	54.793	
10/1 Cottleville Landing.	At Atherton Station, St. Louis, Kansas City and Colorado Railroad, at foot of bluff at angle of road that runs north to Bon Homme Post-office, opposite Cottleville Landing	46.487	43.8
10/2	Is at south line of Olive Street road, 417 feet west of Bosselier's store and 2,589 feet east of the junction of Bon Homme and Olive Street road	45.911	
10/3	Is at Cottleville Landing, at southwest corner of Lewis Haupt's door-yard; 200 feet from the river	58.636	
11/1 Port Royal.	2,000 feet above Port Royal Station, St. Louis, Kansas City and Colorado Railroad, at south fence of railroad right of way; 35 feet west of railroad bridge No. 106; opposite a section house	60.744	48.8
11/2	Is at foot of bluff in angle of Hamburg and Augusta road, where it leaves the bottom and enters the hills; about 3½ miles above Hamburg on land of J. D. Fulkerson	57.635	
12/1 St. Albans.	At St. Albans Station, St. Louis, Kansas City and Colorado Railroad, in northeast corner of Charles Baker's door-yard, 835 feet, S., 85° 30′ W. (mag.), from NE. cor. Sec. 10, T. 44, R. 2 E	65.406	51.8
12/2	Opposite St. Albans, in southwest corner of Jas. A. Cork's door-yard, at foot of bluff	57.907	
13/1 Augusta.	Is at north right-of-way fence, Missouri Pacific Railroad, at a point where railroad leaves the bottom and enters the hills, about one-half mile above Labadie Station	54.772	60.4
13/2	Is at south fence of door-yard of John Rinderer's house on the St Charles County road, about a mile east of Augusta; 210 feet westerly from wagon bridge over small creek at old steam-boat landing	65.361	
14/1 South Point.	Is at south fence of Missouri Pacific Railroad right-of-way at site of old section-house (shown on map). It is about 10,800 feet, measuring along track of railroad below South Point Station in a small recess in bluff	70.714	65.4
14/2	At south fence of county road which runs along the foot of bluff; opposite house of August Strickhuff in SE. ¼ Sec. 17, T. 44, R. 1 E	69.116	
15/1 Washington.	In town of Washington on lot owned by Wm. Miller, on south side Front street and 545 feet, N. 71° 40′ W. (mag.), from west end of railroad station	81.971	69.8
15/2	On left bank, at south fence of field on north bank of Tuque Creek, 2,700 feet from 15/1	66.583	
15/3	Is at north fence of small field on bottom, at point where the Augusta road enters bottom from the hills, about 1 mile west of east line of Warren County	73.112	
16/1	Is at south right-of-way fence of Missouri Pacific Railroad, 3 miles and 2,234 feet below east end of Dundee Tunnel	82.602	74.9
16/2	Is 735 feet west of the center of village of Marthasville (as shown on map), at north fence of road running west, at point where it turns south	78.555	
17/1 Dundee Station.	Is at Dundee Station, Missouri Pacific Railroad, at north fence of small field belonging to S. S. Bailey; 121 feet south of railroad track and 1,530 feet east of Dundee Tunnel	69.350	63.1
17/2	Opposite Dundee Station in southwest corner of Ferdinand Hilbrusch's door-yard at foot of bluff	82.020	
18/1 New Haven.	At New Haven, at north wall of New Haven Merchandise Company's building on corner of Olive street and railroad	90.655	84.8
18/2	Opposite New Haven, at south fence of east and west county road, 5,391 feet, N. 9° 5′ W. (mag.) from 18/1; near residence of H. Hussmeyer	82.750	
18/3	Is at foot of bluff at west fence of road from Pickney Point to bluff (bearing of road N. 26° E., mag.) on north side of lake, about 75 feet from the water	92.127	
19/1 Etlah.	In fence corner made by road and right-of-way fence, Missouri Pacific Railroad, on south side of track, 655 feet, N., 52° 20′ W. (mag.) from Etlah Station. Road bridge over Berger Creek bears N. 72° 35′ E. (mag.) 263 feet distant	97.581	89.5
19/2	Is at south fence of John Clansmeeker's orchard, 100 feet east of small creek; 500 feet from river, opposite Etlah Station, Mo	90.596	
20/1 Berger.	Is in southwest corner of Mrs. M. Schaub's property in southeast corner of Block 15, town of Berger, on Missouri Pacific Railroad	94.264	94.3
	C. S. B. M., 1888. □—cut in top of stone set in ground near 20/1 in town of Berger	98.127	
20/2	Is at foot of bluff about 5,700 feet below Bridgeport, in southwest corner of door-yard of Fritz Etting	99.482	
21/1 Hermann.	At Hermann, at lower end of town on lot of August Wholts, at north side of Front street about 450 feet below railroad bridge over Frame Creek	98.305	100.7

Descriptions and elevations of bench-marks on the Missouri River, etc.—Continued.

No.	Description.	Elevation.	Above the mouth.
	C. S. B. M., 1888. + cut in water table at northeast corner "White House" at Hermann, Mo	*Feet.* 105.888	*Miles.* .....
2_2^1	Opposite Hermann, in northwest corner of property of Henry Clarke, 45 feet south of L'Outre Slough at fence on east side of Hermann road	94.734	.....
2_1^2 Gasconade River.	Is at west fence of garden belonging to Frank Berkl, about 70 feet south of Missouri Pacific Railroad track, and 9,000 feet below mouth of the Gasconade River	107.242	105.6
2_2^2	Is at east fence of lot belonging to E. and W. Heying, in village of Sugartown, is 18 feet east of the front door of their store, 380 feet, N. 6° 45′ E. (mag.), from SE. corner Sec. 25, T. 46, R. 6 W., 6 miles above Hermann, Mo	105.872	.....
2_1^3	Is on Missouri Pacific Railroad about $1\frac{3}{4}$ miles above Gasconade Bridge at north fence of door-yard of Nicholas Wolz	113.147	109.9
2_2^3	At foot of bluff in northeast corner of field belonging to William Boatwright, in SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ Sec. 34, T. 46, R. 6 W., at west fence of lane between Boatwright's and Hoerthis' land	100.341	.....
2_1^4	About $2\frac{1}{8}$ miles above the town of Morrison, at south fence of Missouri Pacific Railroad right of way, 55 feet west of railroad bridge	118.991	115.2
2_2^4	In northwest corner Mrs. Starke's field at NW. corner Sec. 2, T. 45, R. 7 W	101.388	.....
2_3^4	Is at upper end of rock bluff at mouth of Little Tavern Creek	106.284	.....
2_1^5 Chamois.	In town of Chamois, in southwest corner of lot owned by William Cochran, on east side of Main street and 544 feet north of railroad station	116.487	121.1
2_2^5	Opposite Chamois, at north fence of field belonging to Marshall Gibson, 100 feet south of bridge of Stoddard Ferry and Portland road over Mud Creek; 230 feet N. 84° W. (mag.), from Gibson's Mill	105.685	.....
2_1^6 St. Aubert.	Is in the village of St. Aubert, at corner of Main and Morrow streets; west side of Main and north side of Morrow, 300 feet from the river	126.551	126.6
2_2^6	At foot of bluff opposite St. Aubert, in southeast corner of door-yard belonging to T. R. Smith	139.831	.....
2_1^7 IsbellStation.	Is at east fence of right of way of Missouri Pacific Railroad, 258 feet below Isbell Station and 1,230 feet above railroad bridge over Loose Creek	120.487	130.5
2_2^7	At foot of bluff opposite Isbell Station in northwest corner of meadow belonging to Jack Farmer (colored) on east side of Cotesans Dessin road	140.180	.....
2_1^8 Bonnot's Mill.	At Bonnot's Mill (Dauphin P. O.), Mo., at south fence of Missouri Pacific Railroad, 227 feet west of railroad bridge P, and 702 feet west of Bonnot's Mill railroad station house	118.489	134.7
2_2^8	On left bank at north fence of Victor Pinet's garden at east end of Cotesans Dessin, opposite Bonnot's Mill	130.553	.....
2_3^8	On line 2_1^8 to 2_2^8 at north fence of road which runs along foot of bluff, 723 feet northeast of house belonging to Mrs. Ann McCave	139.229	.....
2_1^9 Ewing's Landing.	At Ewing's Landing on south side of road, northeast corner of field, 470 feet from the river and about 500 feet below the end of the bluff at that place	128.268	140.1
2_2^9	Opposite Ewing's Landing, at south fence of pasture belonging to Thomas L. Link, at foot of bluff, about 800 feet west of road, entering hills from the bottom	135.407	.....
3_1^0 Jefferson City,	Is at Jefferson City in east corner of fourth block above Capitol Square, opposite the Ferry Landing, and 280 feet from the river	139.598	146.4
3_2^0	On left bank at south fence of Mrs. M. Wagner's door-yard, 30 feet south of her house, 235 feet, N. 3° 15′ E. (mag.), from southeast corner Sec. 9, T. 44, R. 11 W	129.749	.....
3_3^0	Is at north fence of right-of-way or Fulton Branch of Chicago and Alton Railway, near west end of tangent, which enters the hill from the bottom	147.237	.....
3_1^1	Is 1,166 feet, N. 87° 30′ W. (mag.) from west end of Missouri Pacific Railroad bridge over Gray's Creek, about 2 miles above Jefferson City, Mo., in fence on north side wagon-road	149.799	149.8
3_2^1	Is at foot of bluff in southeast corner of garden of John Yount, about $2\frac{1}{2}$ miles north of Cedar City, Mo. Is N. 55° 50′ E. (mag.) from 3_1^1	132.050	.....
3_1^2 Claysville.	Opposite Claysville, Mo., at west fence of section-line road between Secs. 19 and 20, T. 45, R. 12 W., 1,172 feet south of northeast corner section 19, on land owned by F. Martin	149.124	154.0
3_2^2	Is at upper end of the town of Claysville, Mo., 270 feet below present bridge across creek near its junction with the river; is in small lot owned by D. L. Sitton, and 12 feet north of his house used as drug-store and post-office	143.359	.....
3_1^3 Marion.	Is in the village of Marion, in the northwest corner of Lot No. 30, belonging to J. W. Glenn, about 40 feet north of Glenn's house. It is at south fence of road leading back from the landing and about 475 feet from the river-bank	160.148	161.5
3_2^3	Is at west fence of section-line road, between Sec. 1 and 2, T. 45, R. 13 W., 1,901 feet south of northeast corner section 2, opposite Marion	140.657	.....

Descriptions and elevations of bench-marks on the Missouri River, etc.—Continued.

No.	Description.	Elevation.	Above the mouth.
		Feet.	*Miles.*
$\frac{34}{3}$	Is 2,764 feet from $\frac{34}{2}$ on line $\frac{34}{1}$ to $\frac{34}{2}$ at fence on north side of road which runs between Bonne Femme Creek and foot of bluff, on land of John C. Conley, about 700 feet west of cabin occupied by C. C. Griffen	140.237	.....
$\frac{34}{1}$ Sandy Hook Landing.	Is at Sandy Hook Landing in southeast corner of William Gentzah's front yard, about 600 feet south of one-fourth post between Secs. 11 and 12, T. 46, R. 14 W	167.378	165.5
$\frac{34}{2}$	Is opposite Sandy Hook Landing at fence on west side of road running along foot of bluff about 100 feet below where it meets the Ashland road leading up the bluff	154.279	.....
$\frac{35}{1}$ Providence.	Is at northeast corner of small granary in the William Dethridge estate, from which the one-fourth post between Secs. 22 and 23, T. 47, R. 14 W., is S. 24° W. (mag.) and 737 feet distant	165.146	170.4
$\frac{35}{2}$	Is about 1½ miles below Providence, near foot of bluff, 70 feet west of south end of bridge over Little Bonne Femme Creek, on land of St. Clair, about 600 feet from river	153.896	.....
$35\frac{1}{2}$	Is in the town of Providence, Mo., and stands about 50 feet from Dr. T. S. Rigg's dwelling; it is just inside the wall running in front of the house	181.523	172.0
$\frac{36}{1}$ Wolf's Point.	Is at southwest corner of Musick Zimmerman & Co.'s store at Wolf's Point, Mo. (P. O. Lupus)	173.369	175.0
$\frac{36}{2}$	Is at foot of bluff at a point N. 33° E. (mag.) from $\frac{36}{1}$ on land of J. S. McBain	156.986	.....
$\frac{37}{1}$	Is nearly opposite the middle of Terrapin Island; is at fence which separates wheat and pasture land of H. H. Woolrich; it is 1,460 feet, S. 61° 45′ W. (mag.), from N. E. corner of SE. ¼ of the SE. ¼, Sec. 23, T. 48, R. 15 W., and is 338 feet east of road leading south through the bluffs	169.148	180.3
$\frac{37}{2}$	Is at north fence of road at foot of bluff, 800 feet S. 31° E. (mag.) from wagon bridge over creek which enters Missouri River at Searcey's Landing, about 20 feet above (up-river) from end of vertical rock bluff, where it turns back up the valley of the creek	173.764	.....
$\frac{38}{1}$ Rocheport.	Is at the foot of the bluff, opposite Rocheport, at south fence of small meadow on W. E. Clayton's land; is 880 feet S. 11° 45′ E. (mag.) from center sec. 5, T. 48, R. 15 W	179.258	185.7
$\frac{38}{2}$	Is on right bank, at east fence of section-line road between secs. 4 and 5, T. 48, R. 15 W.; is 328 feet south of northwest corner section 4, 1 mile south of Rocheport	163.660	.....
$\frac{38}{3}$	In town of Rocheport, in southwest corner of lot belonging to the estate of Ran Robinson (colored), on corner of Main and Water streets. The Colored Baptist Church is on the opposite side of Main street	180.340	.....
$\frac{39}{1}$ Elliott's Landing.	Is in northeast corner of orchard belonging to J. E. Elliott, 1,060 feet S. 45° W. (mag.) from Elliott's house at Elliott's Landing, at head of Diana Island	184.088	190.4
$\frac{39}{2}$	Is on left bank, at south fence of Boonville and Rocheport road on township line between Tps. 48 and 49; 500 feet east of northwest cor. sec. 5, T. 48, R. 15 W., on land of Ward Dodson	167.079	.....
$\frac{39}{3}$	Is at foot of bluff on line $\frac{39}{1}$ to $\frac{39}{2}$, about 1,200 feet south of house of Mrs. Jackson Ferris	176.252	.....
$\frac{40}{1}$ Boonville.	Is 6,500 feet down the river from the levee at Boonville at the lower end of the rock bluff that skirts the river, a few feet west of the wagon track that leads up the valley of a small creek, near fence, and about 400 feet from the river bank	173.685	195.9
$\frac{40}{2}$	Is at foot of the bluff, 560 feet west of the east line, and 1,600 feet north of the south line of sec. 28, T. 49, R. 16 W., on land of Mrs. William Edwards. It is 2,362 feet S. 65° E. (mag.) from the iron bridge over Bonne Femme Creek, east of New Franklin	182.548	.....
$40\frac{1}{2}$	Is near stone marking high water of 1844, on west side Main street between Levee and Alley, Boonville, Mo	181.875	197.0
$\frac{41}{1}$	Is at south fence of Missouri Pacific right-of-way, 56 feet from track, 13,500 feet above the Boonville Bridge. [A. B. M. bearing this number was set in 1884, and destroyed by building of the railroad. It was reset as above in 1888.]	203.743	199.9
$\frac{41}{2}$	Is 1,078 feet S. 12° 45′ E. (mag.) from northeast corner sec. 35, T. 49, R. 17 W.; 25 feet east of log cabin of Robert Craig, 2½ miles northwest of Boonville	.....	.....
$\frac{42}{1}$ New Frankfort.	Is at New Frankfort, at foot of bluff at west fence of old ferry road	212.695	240.8
$\frac{42}{2}$	Is on left bank, opposite New Frankfort, at east fence of road on range line between secs. 12 and 7, T. 52, Rs. 18 and 19 W., 75 feet south of northwest corner sec. 7	211.346	.....
$\frac{42}{3}$	Is on section line between secs. 5 and 6, T. 52, R. 18 W., 1,144 feet north of southeast corner sec. 6, an angle having been made at $\frac{42}{2}$ to avoid unfavorable ground	208.768	.....
$\frac{53}{1}$	Is a foot of bluff, 98 feet west of the line between secs. 27 and 28, T. 53, R. 20 W., on land of Samuel Wood, opposite Buck Horn Bend	215.121	253.0
$\frac{53}{2}$	Is at north fence of section-line road between secs. 29 and 32, T. 53, R. 20 W., 480 feet west of southeast corner sec. 29. Left bank	209.253	.....

Descriptions and elevations of bench-marks on the Missouri River, etc.—Continued.

No.	Description.	Elevation.	Above the mouth.
		Feet.	*Miles.*
51 1 Grand River.	Is opposite mouth Grand River; is close to east and west fence, about 20 feet west of southwest corner of NE. ¼ of NE. ¼, sec. 24, T. 53, R. 21 W	220.176	256.7
51 2	Is at east fence of section-line road between secs. 25 and 24, T. 53, R. 20 W.; 382 feet north of one-quarter post between said sections. Left bank, opposite mouth Grand River	218.816	.....
51 3	Is at south fence of section-line road between secs. 13 and 24, T. 53, R. 20 W.; 3,107 feet east of northwest corner section 24	213.409	.....
52 1 De Witt.	Is on line running east and west through center of sec. 22, T. 53, R. 21 W.; 60 feet west of one-quarter post between sections 22 and 23, opposite De Witt, Mo	221.037	262.5
52 2	Is at east fence of section-line road between secs. 15 and 16, T. 53, R. 21 W.; 470 feet north of southeast corner of section 16, opposite De Witt, Mo	220.935	.....
52 3	Is at foot of bluff, in the village of De Witt, Mo.; 55 feet south of center of Jefferson street, in corner of lot owned by W. M. Rogers and 350 feet from Wabash Western Railroad station	233.466	.....
53 1 Miami.	Is in town of Miami, Mo., at northeast corner of brick flouring-mill at Ferry Landing, about 80 feet from edge of water	230.775	266.9
53 2	Is 10 feet from the edge of the north bank of Wakenda Creek, about 400 feet below the wagon bridge on the road from Miami to Miami Station, on the Wabash Western Railroad, on left bank of river	227.880	.....
53 3	Is on a spur of the bluff, 750 feet N. 33° W. (mag.) from the Wabash Western Railroad station-house, at Miami, Carroll County, Mo	278.821	.....
54 1	Is at foot of bluff, about 2¾ miles above the Ferry Landing at Miami, Mo.; it is in about 500 feet a little north of west from corner of field at west side of road and △ Marshall, at a point where the Lanesville road branches off to the west	229.430	272.0
54 2	Is at east fence of section-line road between secs. 13 and 14, T. 52, R. 22 W.; 1,106 feet north of one-quarter post between said sections; 200 feet south of Wabash Western Railroad crossing, on land of William Smith	231.994	.....
55 1 Lanesville.	Is 100 feet northwest from McBride Hay's residence; is 2,119 feet north of southwest corner of Sec. 3, T. 51, R. 22 W., about 2 miles southeast of Lanesville, Mo	293.751	281.4
55 2	Is on right bank, at north fence of township-line road between townships 51 and 52; is 4,379 feet west of southeast corner of sec. 33, T. 52, R. 22 W., and 120 feet east of bridge over Davis Lake; 1½ miles southeast of Lanesville, Mo	237.801	.....
55 3	Is at south fence of township-line road between Tps. 51 and 52, R. 22 W., and 1,681 feet east of northwest corner section 4	236.755	.....
56 1 Gillam's Landing.	Is 4 feet north of south fence of section-line road between secs. 5 and 8, T. 51, R. 23 W.; is 1,106 feet west of southeast corner section 5, and 158 feet east of a point in road in front of house owned by S. H. Moore	245.138	287.0
56 2	Is on right bank, 2,735 feet from the river at Gillam's Landing; is 330 feet N. 38° 30′ E. (mag.) from Calvin Phlegan's house, at fence on south bank of slough	246.573	.....
56 3	Is at east fence of road on half section line which runs north and south through center of sec. 6, T. 52, R. 22 W., and is 113 feet south of southwest corner of NW. ¼ of SE. ¼ of said section 6, or about 1,433 feet south of center of section	238.328	.....
57 1 Waverly.	Is in corner of field, 177 feet S. 59° 30′ E. (mag.) from a point on section-line between secs. 12 and 13, T. 51, R. 24 W., which point is 460 feet west of the one-quarter post between said sections; about 1¼ miles northeast from Waverly, Mo., on land owned by Charles Walton	245.602	296.4
57 2	Is 3 feet north of south fence of section-line road between secs. 7 and 18, T. 51, R. 23 W.; 2,203 feet east of northwest corner section 18	251.309	.....
59 1	Is in northwest corner of William Milliner's yard, near an elm, 3′ diameter, in the town of Waverly, Mo.; 1,700 feet below the foot of Washington street; 60 feet south of railroad track	271.019	297.2
59 1	Is 200 feet south of a point on the Missouri Pacific Railroad, which point is 60 feet west of railroad bridge No. 47; about 4 miles above Waverly, Mo	283.906	301.3
59 2	Is in apparent center of road running between secs. 10 and 3, T. 51, R. 24 W., at a point 139 feet of one-qaurter post between said sections	252.027	.....
60 1 Dover.	Is 15 feet west of northwest corner of Henry Neff's house; 200 feet south of Missouri Pacific Railroad track, about 2½ miles below Dover station; is in NW. ¼ of SE. ¼ of sec. 9, T. 51, R. 25 W	267.268	305.4
60 2	Is on left bank, 7,251 feet nearly due north from 60 1 in east and west road between sec. 1 and 12, T. 51, R. 25 W; is about 1,840 feet east of northwest corner section 12, and 400 feet east of Thomas Spurwell's house; is 3 feet north of south fence of road	257.635	.....
60 3	Is 7,730 feet nearly due north of 60 2, and is 792 feet west of center of sec. 36, T. 52, R. 25 W., in county road, 3 feet north of south fence, 683 feet west of J. S. Wilson's house, and 280 feet east of Henry Tate's house	259.914	.....

A 5.

REPORT OF MR. O. B. WHEELER, ASSISTANT ENGINEER.

OFFICE MISSOURI RIVER COMMISSION,
St. Louis, Mo., May 21, 1890.

SIR: I have the honor to submit the following report of field work on secondary triangulation of the Missouri River during the season of 1889, together with the reduction of the Buford base line.

FIELD WORK.

The work under my charge was to construct two quarter-boats at Fort Benton, Mont., from materials shipped there by railroad, to drop 240 miles to the close of the work of 1885 at Trover's Point, and then carry the triangulation down to connect with that being done by Assistant Engineer G. A. Marr, below Bismarck, N. Dak.

In accordance with instructions I left St. Louis on March 26, going by way of Bismarck, where I assisted Mr. Marr to make two measurements of our common base line, and arrived at Fort Benton on April 11. Assistant Engineer R. F. Grady, arriving on April 1, had received the materials for the boats which came on March 28, and had the hulls well under way, employing such help as could be found there, except two carpenters who had been sent from below and who were to act as mates of quarter-boats through the season. The mates were Mr. Robert L. Hazen from Sioux City, Iowa, and Mr. J. M. Wilkins from Osceola Mills, Wis. Before the day of setting out, April 25, Assistant Engineer E. E. Wall, four recorders, and one rodman had arrived.

The party was organized as follows, quartered on two quarter-boats with two skiffs to each quarter-boat, and a raft for the pack-horse:

One assistant engineer (in charge), 1 rodman, 1 mate, 1 cook, 1 foreman, 1 boatman, 1 laborer with horse, and 3 laborers on quarter-boat No. 5.

Two assistant engineers, 2 first recorders, 2 second recorders, 1 mate, 1 cook, 1 boatman, and 6 laborers on quarter-boat No. 6.

On May 6 Forgey's Landing at Trover's Point was reached and practice work immediately begun. Of the 101 sets of marking stone and pipe left there in 1885, 94 sets were found and taken on board, and, later, 63 sets from the 70 sets left at Galpin were found and taken on board. On May 8 the regular work was taken up and closed at Bismarck on November 21, and the party left the field on the 23d. The river distance of 592 miles (as estimated) was covered in one hundred and ninety-seven days (including smoky and stormy days and Sundays), or, at a rate of 3 miles per day. Of the one hundred and ninety-seven days, fifty-three were too smoky and eight too stormy for observation, and twelve were consumed in the base-line and azimuth work. The season was unusually dry, and the river never known so low. The smoke from the mountain forest and prairie fires was very dense, for the Indians were burning the prairies that the buffalo bones could the more easily be secured for market at the railroad stations.

A quadrilateral system of triangulation was secured throughout with base-lines about 200 miles apart, in axial distance, at Trover's Point, Fort Buford, and Bismarck. One hundred and ten stations were located and marked; but at four points, namely, Rock Peak, Round, Tiger, and Lion Buttes, only an iron rod driven in a rock crevice gives the place of the station. Only one timber-station was needed, and that was a 12-foot station at △ east base, Fort Buford, in order to secure a 2-mile base-line. The large portable tripods were used instead of timber-stations, and umbrellas and canvas were used to shield from sun and wind.

Mr. Grady, observer on the right bank, used the Troughton & Simms non-repeating 10-inch theodolite No. 1, while Mr. Wall, observer on the left bank, used the Gambey repeating 10-inch theodolite No. 1. With the Troughton & Simms theodolite, as formerly, eight combined results were obtained, and with the Gambey four combined results, positive and negative, repeating three times on each angle for a single positive or negative result. This made the accuracy and labor with the two theodolites about the same. The angle closing the horizon was measured at all stations. The former instrument was used in observations for azimuth and for approximate latitude and time, and the chronometer used in this connection was Hutton No. 353. Five nights of azimuth work on stars near elongation were done at Fort Buford and two at Bismarck.

Measurements of the Buford base were made on three successive evenings, by daylight, but when the sun's heat was cut off by haze and smoke. The average time consumed to make a measurement was one hour. The method of measurement was the same as given in the Chief of Engineers' Report for 1887, page 2,952. The microscopes prepared in the spring for use in this connection were discarded, since having no cross-wires, a slight disturbance in their position might tend to increase rather than to lessen error from parallax in recording on the zinc strips.

A continued series of vertical angles from Trover's Point base to Buford base, and continued to the Bismarck Bridge were observed with the Troughton & Simms theodolite.

The qnarter-boats Nos. 5 and 6 were hauled out at Rock Haven, 4 miles north from Mandan, N. Dak., on a level bank 23 feet above the water, and were left in charge of Mr. Henry Geries as watchman.

Messrs. Grady and Wall, and Recorder E. D. Williams, arrived with myself at this office on November 26. I am under obligation to these gentlemen, and the other recorders, and the rodman for faithful service rendered.

RÉSUMÉ OF FIELD WORK.

Quarter-boats built	2
Base-lines measured	1
Stations located and occupied	110
Buildings, land survey marks, etc., connected with	35
Angles measured in main system	553
Angles measured to locate points	72
Vertical angles measured	235
Azimuth observations, number of nights	7
Miles of river covered (estimated)	592

BASE-LINE REDUCTION.

The three measurements of the Buford base were made under very favorable conditions of weather and temperature by daylight, when the sun through the haze scarcely cast a shadow, or when the thermometer in shade would read the same as when exposed to the sun. The Missouri River Commission Tape No. II was used with a 16-pound tension, the same as used in comparing this tape with the Mississippi River Commission standard. The adopted value for Tape II at 62° Fahr. under 16-pounds tension, and supported at every 30 feet in anti-friction hooks is $=300'.03851$, and the co-efficient of expansion for 1° Fahr. $=0'.00000687$. (See Appendix W W, page 2759, Chief of Engineers' Report for 1889.)

The thermometers used were made by H. J. Green, 771 Broadway, New York, and were carefully compared with a standard air thermometer in the United States Signal Office at Washington, D. C. .(See table appended.) The corrections for the thermometers used are not greater than one-tenth of a degree, or practically nothing, since it was impracticable to read with accuracy to the tenth of a degree.

In comparing the second measurement with the first a slight mistake was found to exist at Stake 36 in the zinc strip record and, on the third measurement, the mistake was found to have been made in the first, and a remeasurement was made from Stake 35 to take the place of the last three tapes' length of first measurement.

The elevation of the base-line depends on the track at Buford Station=1,950 feet, as used by the Signal Service at Fort Buford, and as furnished from the office of the St. Paul, Minneapolis and Manitoba Railroad, this depending also on the elevation of the intersection of this railroad with the Northern Pacific at Glyndon, Minn., as 924 feet, and of the mean low water of Lake Superior as 600 feet.

The reductions have been made in duplicate. Two of the results are practically identical, and the probable error for the mean of the three is one-fourth of an inch, or 1 in 570,000 parts of the base, the length reduced to sea-level being $11,400'.347$.

Tables of the observations and reductions are herewith appended.

Very respectfully, your obedient servant,

O. B. WHEELER,
Assistant Engineer.

First Lieut. J. C. SANFORD,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

MEASUREMENTS OF THE BUFORD BASE.

The three measurements of Buford base are expressed by the following equations:

(1) $[38 \times 300'.0385] + 1'.253 + 0'.500 - 1'.554 - 0'.206 = 11401'.456.$
(2) $[38 \times 300'.0385] + 0'.530 + 0'.667 - 1'.088 - 0'.206 = 11401'.366.$
(3) $[38 \times 300'.0385] + 0'.894 + 0'.584 - 1'.369 - 0'.206 = 11401'.366.$

Mean $= 11401'.396 \pm 0'.020.$

First term is number of tapes multiplied by length of tape at 62° Fahr.

Second term is temperature correction to reduce 38 tapes at tape temperature to 62° Fahr.

Third term is distance set forward on zincs.

Fourth term is distance between end of last tape and △ west base.

Fifth term is correction for inclination of tape.

The second member is the corrected independent result for each measurement.

The mean of three measurements = 11401′.396 ± 0.′020.

Correction to reduce to sea-level = — 1′.049.

Buford base reduced to sea-level = 11400′.347 ± 0′.020.

Mean elevation of Buford base below railroad track at Buford = 26′.42.

Elevation of railroad track at Buford above sea-level = 1950′.00.

Mean elevation of Buford base above sea-level = 1923′.58.

Correction to reduce to sea-level = — 1′.049.

Buford base—Temperatures during measurements.

No. of tape.	First measurement.			Second measurement.			Third measurement.		
	Aug. 5, 1889. Time, p. m.	Thermometers.		Aug. 6, 1889. Time, p. m.	Thermometers.		Aug. 7, 1889. Time, p. m.	Thermometers.	
		5101	5103		5101	5103		5101	5103
	H. M.	° F.	° F.	H. M.	° F.	° F.	H. M.	° F.	° F.
1	6 25	82.4	82.75	5 44½	71.2	70.8	5 33	77.2	77.0
2	30	83.0	82.0	46	71.3	70.8	35	77.1	76.8
3	32	82.9	81.8	47½	71.6	71.0	36½	77.0	76.9
4	34	82.4	81.2	49	71.4	70.9	38	76.5	76.5
5	36	82.1	81.2	51	71.1	70.7	40	76.5	76.6
6	38	81.6	81.1	52½	71.0	70.5	42	76.3	76.0
7	40	81.4	80.0	56	70.5	69.9	43½	76.2	75.9
8	49	80.6	79.9	58	70.3	70.0	45	76.1	75.9
9	53	80.6	79.4	6 00	70.4	69.8	47	76.0	75.6
10	55	80.8	80.0	01½	70.1	69.7	48½	75.6	75.5
11	57	81.0	80.5	03	70.0	69.4	50	75.4	75.2
12	59	80.9	80.1	04½	69.7	69.0	52	75.3	74.9
13	7 01	81.0	79.4	06	69.5	69.0	53	75.0	74.6
14	03	80.9	79.75	07½	69.2	69.1	54½	74.6	74.3
15	05	80.3	79.5	09	69.4	69.1	56	74.4	74.3
16	07	79.8	79.0	11	69.5	69.0	58	74.0	74.0
17	11	79.5	78.25	13	69.5	69.1	59½	74.0	74.0
18	13	79.0	78.4	14½	69.5	69.1	6 01	74.5	74.0
19	15	78.6	77.75	16	69.1	69.0	03	74.0	74.9
20	17	79.1	77.4	18	69.1	68.6	04½	73.7	73.2
21	19	78.5	77.5	19½	69.2	68.7	06	73.4	73.1
22	21	78.4	78.0	21	69.0	68.5	07	72.7	73.0
23	23	78.0	77.6	22½	68.6	68.5	08½	72.2	71.8
24	25	78.1	77.0	24	68.5	68.0	10	72.5	71.7
25	26½	78.0	77.6	25½	68.4	68.0	11	72.5	72.3
26	28	78.0	77.4	27	68.5	68.1	12½	72.0	72.0
27	30	78.0	77.0	28½	68.3	68.2	14	71.9	71.6
28	32	77.6	77.0	30	68.0	68.5	15½	71.5	71.3
29	34	77.2	77.0	31½	67.6	68.2	17	71.5	71.0
30	36	77.3	77.0	33	67.5	68.0	18½	71.3	70.8
31	38	77.8	77.0	34½	67.8	67.5	20	71.0	71.0
32	40	77.9	77.1	36½	67.6	67.0	21½	71.1	70.6
33	42	77.5	77.9	38	67.4	67.0	23	71.3	71.0
34	44	79.0	78.5	39½	67.2	66.9	24	71.4	71.0
35	7 46	79.1	78.5	41	67.1	66.8	25½	71.5	71.2
36	*6 36	68.3	68.4	42½	67.1	66.8	27	71.1	71.0
37	40	67.7	67.7	44	67.0	67.0	28½	70.6	70.5
38	44	66.9	66.2	46½	67.1	66.8	30	69.8	69.5
	Means.	78.72	77.99	.....	69.09	68.76	.....	73.65	73.41

*August 7, remeasured on account of a mistake on tape 36 on first measurement, as shown by the zinc-strip record.

NOTE.—On the second measurement a break in the mercurial column of thermometer No. 5101 was found, causing this thermometer to read higher than the other. We were unable to reduce it entirely, and, since it was there, probably, during the first measurement, the readings from this thermometer have not been used in the reductions.—O. B. W.

Correction for inclination of tape on Buford base.

[l = length of tape; $\sin i = z$; correction $= l \times$ ver sin $i = l \times 2 \sin^2 \frac{1}{2} i$; i = angle of inclination; h = difference of elevation.]

No. of stake.	Elevation.	Difference of elevation.	Log. difference elevation. Log. h.	Log. h — log. l = log. sin i.	i	Log. $\sin^2 \frac{1}{2} i$	Log. $\sin^2 \frac{1}{2} i$ + log. $2l$ = log. correction.	Correction.
	′	′			′ ″			′
△ E. B	6.07							
Zinc E. B	8.04							
1	11.00	3.06	0.48572	8.00854	35 04	5.41518	8.19339	0.0156
2	13.04	1.94	0.28780	7.81062	22 14	5.01940	7.79761	0.0063
3	13.68	0.64	9.81023	7.33305	07 24	4.06389	6.84207	0.0007
4	15.59	1.91	0.28035	7.80317	21 51	5.00496	7.78317	0.0061
5	14.63	0.96	9.98227	7.50509	11 00	4.40818	7.18639	0.0015
6	15.14	0.51	9.70757	7.23039	05 51	3.86218	6.64039	0.0004
7	15.41	0.27	9.42975	6.95258	03 05	3.29872	6.07693	0.0001
8	13.53	1.88	0.27416	7.79698	21 32	4.99162	7.76983	0.0059
9	11.35	2.18	0.33826	7.86108	24 58	5.12012	7.89833	0.0079
10	11.36	0.01	7.69897	5.22179	00 03	9.97320	2.75141	0.0000
11	10.48	0.88	9.94448	7.46730	10 05	4.33116	7.10937	0.0013
12	8.08	2.40	0.37985	7.90267	27 28	5.20300	7.98121	0.0096
13	6.50	1.58	0.19866	7.72148	18 06	4.84074	7.61895	0.0042
14	3.27	3.23	0.50920	8.03202	37 01	5.46180	8.24001	0.0174
15	0.76	2.51	0.39898	7.92180	28 43	5.24216	8.02037	0.0105
16	1.80	1.04	0.01536	7.53818	11 52	4.47404	7.25225	0.0018
17	1.55	0.25	9.39794	6.92076	02 52	3.24014	6.01835	0.0001
18	0.00	1.55	0.19005	6.71287	17 45	4.82298	7.60119	0.0040
19	0.59	0.59	9.77232	7.29514	06 47	3.99040	6.76861	0.0006
20	5.23	4.64	0.66652	8.18934	53 10	5.77666	8.55487	0.0359
21	5.25	0.02	8.27875	5.80157	00 13	1.06134	3.83955	0.0000
22	5.34	0.09	8.94448	6.46730	01 00	2.32540	5.10361	0.0000
23	7.44	2.10	0.32222	7.84504	24 04	5.08822	7.86643	0.0074
24	9.29	1.85	0.26717	7.78999	21 12	4 97806	7.75627	0.0057
25	11.59	2.30	0.36173	7.88455	26 21	5.16750	7.94571	0.0088
26	14.85	3.26	0.51322	8.03604	37 21	5.47036	8.24857	0.0177
27	14.63	0.22	9.33445	6.85727	02 29	3.10962	5.88783	0.0001
28	14.92	0.29	9.45332	6.97614	03 15	3.35360	6.13181	0.0001
29	16.50	1.58	0.19866	7.72148	18 06	4.84074	7.61895	0.0042
30	17.62	1.12	0.04883	7.57165	12 49	4.54208	7.32029	0.0021
31	20.40	2.78	0.44436	7.96718	31 52	5.33206	8.11027	0.0129
32	21.21	0.81	9.90848	7.43130	09 17	4.25924	7.03745	0.0011
33	23,23	2.02	0.30535	7.82817	23 09	5.05386	7.83207	0.0068
34	24.15	0.92	9.96661	7.48943	10 37	4.37600	7.15421	0.0014
35	23.48	0.67	9.82607	7.34889	07 41	4.09460	6.87281	0.0008
36	22.79	0.69	9.84323	7.36605	07 59	4.13158	6.90979	0.0008
37	21.23	1.56	0 19312	7.71594	17 52	4.82948	7.60769	0.0040
Zinc W. B	22.37	1.14	0.04690	7.56972	12 46	4.53754	7.31575	0.0021
△ W. B	21.03							
Total								—0.2059

Mean elevation of base above lowest point = 12.24
Mean elevation of base below △ west base = 8.79
Elevation of △ west base below railroad track at Buford Station = 17.63
Elevation at △ west base is for top of cap of pipe, or about surface of ground.

Buford base.—Measured differences on zincs.

Second measurement—first measurement.				Second measurement—third measurement.		
No. of tapes.	Readings on zincs.	Correction.	Reduced.	Readings on zincs.	Correction.	Reduced.
	"	"	"	"	"	"
1	+0.23	.....	+0.23	+0.14	.....	+0.14
2	+0.47	.....	+0.47	+0.30	.....	+0.30
3	+0.69	.....	+0.69	+0.45	.....	+0.45
4	+0.94	.....	+0.94	+0.54	.....	+0.54
5	+1.14	.....	+1.14	+0.66	.....	+0.66
6	+1.34	.....	+1.34	+7.79	*−7.00	+0.79
7	−6.40	†+8.00	+1.60	−0.06	†+1.00	+0.94
8	−0.14	‡+2.00	+1.86	+0.03	.....	+1.03
9	+0.05	.....	+2.05	+0.22	.....	+1.22
10	+0.28	.....	+2.28	+0.36	.....	+1.36
11	+0.53	.....	+2.53	+0.48	.....	+1.48
12	+0.76	.....	+2.76	+0.65	.....	+1.65
13	+1.02	.....	+3.02	+0.80	.....	+1.80
14	+1.22	.....	+3.22	+0.94	.....	+1.94
15	+1.43	.....	+3.43	+1.04	.....	+2.04
16	+1.65	.....	+3.65	+1.13	.....	+2.13
17	+1.84	.....	+3.84	+1.23	.....	+2.23
18	+2.02	.....	+4.02	+1.33	.....	+2.33
19	+2.17	.....	+4.17	+1.42	.....	+2.42
20	+2.33	.....	+4.33	+1.52	.....	+2.52
21	+2.49	.....	+4.49	+1.63	.....	+2.63
22	+2.73	.....	+4.73	+1.72	.....	+2.72
23	+2.86	.....	+4.86	§+1.82	.....	+2.82
24	+3.10	.....	+5.10	+1.93	.....	+2.93
25	+3.30	.....	+5.30	+2.03	.....	+3.03
26	+3.50	.....	+5.50	+2.13	.....	+3.13
27	+3.69	.....	+5.69	+2.22	.....	+3.22
28	+3.90	.....	+5.90	+2.35	.....	+3.35
29	+4.10	.....	+6.10	+2.46	.....	+3.46
30	+4.28	.....	+6.28	+2.56	.....	+3.56
31	+4.49	.....	+6.49	+2.66	.....	+3.66
32	+4.72	.....	+6.72	+2.74	.....	+3.74
33	+4.97	.....	+6.97	+2.84	.....	+3.84
34	+5.22	.....	+7.22	+2.96	.....	+3.96
35	+5.50	.....	+7.50	+3.11	.....	+4.11
36	+5.55	.....	+7.55	+3.22	.....	+4.22
37	+5.59	.....	+7.59	+3.31	.....	+4.31
38	+5.59	.....	+7.59	+3.36	.....	+4.36

*Set forward 7″.00 on zinc No. 5, third measurement.
†Set forward 8″.00 on zinc No. 6, second measurement.
‡Set forward 6″.00 on zinc No. 7, first measurement.
§Supplied—Zinc No. 23 disturbed between second and third measurements.

"SIGNAL OFFICE, WAR DEPARTMENT,
Washington City, February 12, 1889.

Corrections to reduce to an air-thermometer.

Thermometer readings.	Nos. of thermometers. (H. J. Green, N. Y.)					
	5100	5101	5103	5107	5108	5114
	°	°	°	°	°	°
32	+0.2	0.0	0.0	+0.1	0.0	+0.1
42	+0.2	0.0	0.0	0.0	−0.2	0.0
52	+0.1	−0.1	0.0	0.0	−0.1	0.0
62	+0.1	0.0	0.0	0.0	−0.3	0.0
72	0.0	−0.1	−0.1	0.0	−0.2	−0.1
82	0.0	−0.1	0.0	0.0	−0.2	−0.1
92	0.0	−0.1	−0.1	−0.1	−0.2	−0.1
102	+0.1	−0.1	−0.1	−0.2	−0.2	0.0

T. RUSSELL.

"I. The correction is to be applied directly to the scale reading; when +, to be added, when —, to be subtracted.

"For scale readings intermediate to those for which the table is given, interpolated values of the corrections are to be used.

"II. Special attention is called to the application of the correction when the thermometer reads below 0°. If, for example, the correction at —28°.0 is —2°.5, then for the reading —28°.0 the true temperature is —28°.0 —2°.5= —30°.5. If, on the other hand, the correction is +2°.5, then the true temperature is —28°.5+2°.5= —25°.5.

"III. Mercurial thermometers are liable, through age, to change their corrections.

"In future, therefore, when testing the thermometers in melting ice, if a different correction at 32° from that here given is found, the whole series of corrections is different by a constant quantity equal to the change in the freezing point.

"Signal-service observers, however, will not change corrections without further authority."

A 6.

REPORT OF MR. G. A. MARR, ASSISTANT ENGINEER.

OFFICE MISSOURI RIVER COMMISSION.
St. Louis, Mo., May 19, 1890.

SIR: I have the honor to submit the following report of field work on secondary triangulation of the Missouri River, and reductions of base-lines measured during the season of 1890:

FIELD WORK.

With instructions from the office to proceed to Bismarck, Dak., by the way of Wabasha, Minn., to inspect lumber for four quarter-boats, I left St. Louis on March 17, arriving at Wabasha on the evening of March 18. As a part of the oak timber for the quarter-boats was not ready, the inspection was not completed till the afternoon of March 21.

Eight skiffs and thirty-two oars were also purchased at Wabasha to be shipped with the lumber, four skiffs with lumber for two quarter-boats to Fort Benton, Mont., and four with lumber for two quarter-boats to Bismarck, N. Dak. Stopped at St. Paul, Minn., to look for a ship-carpenter to take charge of building the quarter-boats at Bismarck, but was not able to persuade any one to go on terms possible for me to offer.

Left St. Paul for Bismarck on March 23, and arrived at Bismarck on the 24th at noon. The preparations for building the two quarter-boats, and for reconnaissance for base-line and triangulatiou, were commenced immediately. The lumber for the quarter-boats arrived on the 26th, and work was commenced on them on the 27th, a carpenter, Mr. M. S. Moore, being found in Bismarck who had done some work in repairing boats.

Mr. J. J. Sanders, assistant engineer, arrived on the 26th of March, and Assistant Engineer O. B. Wheeler on the 29th. As I had a base-line selected, Mr. Wheeler looked over the ground and took charge of preparing the line for measurement, while I continued the reconnaissance for triangulation and looked after the building of quarter-boats. The base-line was fully prepared on April 6, and a measurement made after 8 p. m., Assistant Engineer Wheeler being in charge of the measurement. On the 8th of April, after 8.40 p. m., a second measurement was made, and Mr. Wheeler left for Fort Benton, Montana, at noon on the 9th. On reducing the two measurements of the base-line they were found to differ materially, and hence it was decided to make other measurements, one being made April 15, in the afternoon, and another in the forenoon of April 16, both made during cloudy weather. These two measurements when reduced fell between the two previous measurements and were considered sufficient.

On April 20 Mr. Reeves Smith reported for duty, which made the number of assistant engineers and recorders complete. Mr. Smith, having had experience in measuring angles, was assigned to duty as assistant engineer, and the work on secondary triangulation was fully inaugurated.

One quarter-boat, No. 7, was completed April 20, and its outfit and supplies of provisions were taken on board. On the 21st the assistant engineers and recorders all moved to quarter-boat No. 7, until quarter-boat No. 8 should be in readiness. This was completed on the 24th, and all employés then located on the boats.

The work of reconnaissance had been carried on sufficiently, while the boats were being built, so that eight stations had been put up, and observations made as fast as the weather would permit, the dry, dusty air, with more or less wind, making observations difficult, especially those for azimuth, as the mercury used for artificial horizon would be covered with dust in a few minutes.

Quarter-boat No. 7, with reconnoitering and station building party, left Bismarck on April 30, and moved on down to the vicinity of work ahead, and was followed by the observing parties on quarter-boat No. 8 on May 2, Assistant Engineer J. J. Sanders being in charge. Had no regular pilot or mate till the arrival of Mr. L. A. Dale on May 2, when he joined quarter-boat No. 7, about 30 miles below Bismarck.

The work progressed quite favorably until reaching the Indian reservation on the right bank below Cannon Ball River. At this point the Indians were decidedly opposed to having any survey on their lands, and especially to having any permanent marks set. The Indian agent, Maj. James McLaughlin, at Standing Rock Agency, Fort Yates, was seen in regard to the work, and all authority possible obtained, the Indian police being instructed to protect our stations. But the trouble continued at the second point on the reservation until the observing parties had managed to get their observations by putting up the target during the day and taking it down again at night. After this point was passed there was no more serious trouble with the Indians.

On account of the very dry season the work was much delayed by smoke after the middle of June.

The base-line at Pierre, S. Dak., that had been selected in October, 1888, was measured in July, there being five measurements, the first one at night and then four during cloudy days. This base-line was over meadow and pasture land for its whole length, and was mowed over especially for this work; and a very good measurement was obtained. The observations for azimuth were interfered with by cloudy nights, which delayed the work somewhat.

At Pierre, Mr. C. W. Williams was made overseer in place of M. Reeves Smith, who resigned and left the work.

On reaching the vicinity of Niobrara, Nebr., the reconnoitering for stations was made with reference to locating a base-line, and a good level stretch of bottom land was found just below Running Water, S. Dak., and, after locating the line, it was run over with a mowing-machine to free it from tall grass and weeds. This line was also selected so as to avoid passing over cultivated ground, and what was considered a very good line was prepared and measured five times over thirty-seven tape lengths and six times over ten tape lengths that passed through a pasture. This base was divided into two parts for measurement, on account of finding the stakes disturbed in the pasture when we had arrived at the thirty-seventh tape length during the first measurement. As this measurement was made at night, these stakes could not well be reset till the next day. After these stakes were reset, four consecutive measurements were made of the ten tape lengths by keeping the cattle away from that part of the pasture. This base-line was measured in October, and the usual observations for azimuth made. The greater than usual number of measurements were made on this base on account of differences in measurement seeming larger than could be accounted for.

All the bases were measured by the same method as fully described in Report of the Missouri River Commission for 1886, the same tension apparatus being used—only in addition to that method two small microscopes were used, one at each end of the tape, to assist in setting and marking on the zinc strips. Two marking stakes were used at each point capped with a piece of board about 4 by 20 inches, to which was nailed the strips of zinc in the direction of the base-line, the boards being placed enough to one side of the line so that the zinc strips would come on one edge, leaving the other edge for placing the microscopes. These microscopes were mounted on lead bases about $\frac{3}{4}$ by 2 by 3 inches, which were provided with three small iron points to hold them firmly to the platform boards containing the zincs. The front microscope was set by the observer at that end of the tape and used to mark the end graduation on the zinc. This microscope then remained undisturbed for the observer at the rear end to set his graduation mark, intending by this means to avoid parallax from the observers using different positions for their eyes. After a tape length was marked a runner carried the rear microscope forward.

The instruments used for measuring angles were the Troughton & Sims 10-inch theodolite No. 2 and the Gambey-Würdeman 10-inch theodolite. With the T. & S. instrument the readings were taken positive and negative with change of circle and telescope reversed, obtaining 8 combined results for each angle; and with the Gambey-Würdemann five pointings for a repeated single result were taken, positive and negative, with change of circle and telescope reversed, obtaining four combined results for each angle. The limit for closure of triangles was 6 inches, but out of the

whole system of triangles 77 per cent. closed within the limit of 3 inches, which is allowed for primary work.

During the first of the season the work was much delayed by the failure to get reliable work with the Gambey-Würdemann instrument. One defect that could be remedied in the field was found, and after this cause of trouble was removed the instrument did very good work for a time, but it could not be relied on in windy weather, as its telescope was too light and unsteady in the V supports for good work when there was much wind.

At Running Water, S. Dak., the Troughton & Simms 12-inch repeating theodolite was received and used in the place of the Gambey-Würdemann from that point down. The same method was used for observing angles with this instrument as with T. & S. No. 2.

From Pierre down, many of the triangulation points of Capt. D. W. Wellman's surveys of 1881 and 1882, being marked with 2-inch gas-pipe, were found and connected with, and each triangulation station was connected with land survey marks where possible, and public buildings and prominent points were generally located in connection with the work.

The reconnoitering was very thorough, and gave a good system of triangles over the whole distance from Bismarck to Sioux City, no regular triangle in the system having an angle less than 30°, and all covered by consecutive quadrilaterals. The points were also so selected that no stations had to be built to elevate the instrument, the usual tripods being used at all points.

The stations were marked with the usual stone and pipe fully described in former reports, the stone being set 3 feet below the surface of the ground, and the 4-inch gas-pipes, 3 feet long, plumbed with the center mark in the cast-iron cap of the pipe, carefully centered over the center mark in the stone, and the soil firmly packed around the pipe. These pipes were used at all the stations, and the regular marking stones at all the stations except three, where the hills were so full of rock that the usual marking stone could not be set low enough, and the rock on the hills was used by making a cross (+) mark for center, and cutting the letters U. S. with a cold-chisel. The points thus marked were △ St. Benedict, near St. Benedict Mission, △ Barth, just below Pierre, S. Dak., and △ Ponca, about 12 miles northwest of Niobrara, Neb. At △ Ponca the target and pipe were destroyed before the observations were completed, but the center mark on the stone was not disturbed, and the work was completed by renewing the target and pipe. As the center mark for this station was not considered very permanent, three surface marks were made in the solid rock in different directions to preserve the location. These are fully described in the field-notes.

The party reached the vicinity of Sioux City, Iowa, about the middle of November, and the quarter-boats Nos. 7 and 8 were hauled out and placed on the bank in a well-sheltered place in Riverside Park, about 3 miles above Sioux City. A part of the crew were paid off November 19, and others as the work would admit, until, on November 25, all were paid off except Assistant Engineer J. J. Sanders, who was to return to the office in St. Louis, and Mr. L. A. Dale, who was to remain as watchman on the two quarter-boats.

Mr. Sanders and myself left Sioux City, Iowa, on the morning of November 26, and reached St. Louis, Mo., about noon, November 27, 1889.

The following table gives a concise statement of the amount of work during the season:

Quarter-boats built	2
Base-lines measured	3
Stations located and occupied	136
Angles measured in main system	678
Observations of azimuth, number of nights	7
Triangulation points, surveys 1881 and 1882, located	27
Public buildings, prominent points, etc., located	43
Land survey marks connected with	25
Miles of river covered, about	625

The stage of water was very low during almost the entire season, the usual June rise only amounting to about 3 feet. This made navigation with quarter-boats, mostly propelled by the current, quite difficult, especially when there was much wind. But no serious delay was experienced from this cause during the season; and no damage happened to the boats, both being in good condition at the close of the season.

The assistant engineers and recorders during the season rendered good and faithful service, and I feel grateful to them for the interest they manifested in the work.

REDUCTION OF BASE-LINES.

These bases were all measured by the same methods as those given with full details in the Annual Report of the Chief of Engineers.

The Missouri River Commission Tape No. III was used with a 16-lb. tension, the same as used in comparing this tape with the standard. The length of Tape No. III at 62° Fahr.=300′.02398, and having a co-efficient of expansion=0.00000691. For length of tape and co-efficient of expansion, see Annual Report of the Chief of Engineers for 1889, Appendix WW, page 2759.

The thermometers used were made by Green, of New York, and were carefully compared with the Standard in the Signal Service Office at Washington, D. C. A report on these thermometers is given by Assistant Engineer O. B. Wheeler, with the thermometer corrections.

In connection with these reductions, there have also been made comparisons between measurements by means of the zinc strip records, which make it possible to examine the differences between measurements for each tape length, using values derived from differences in temperature and co-efficient of expansion, and comparing these with the actual measured differences on the zincs. These quantities generally agree to within a few hundredths of an inch, and by this means any use of a wrong graduation mark by an observer while making measurements can be detected with certainty. One such error occurred during this work in the third measurement of the running water base, the graduation mark 299.9 feet being used instead of the 300-feet mark.

The computations for the reductions of these base-lines have been made by myself, and, as to the lengths of the base-lines, checked by Assistant Engineer O. B. Wheeler.

There were four measurements of the Bismarck Base. The first, on account of some irregularities and its being a practice measurement, was not used. The probable error of the three measurements used is .025′, or about 1 in 666,000, the length of the base reduced to sea level being 16,649.55′.

There were five measurements of the Pierre Base. On account of imperfect lining of the supporting stakes for the tape, the first measurement was not used. This measurement was made at night, and the irregularities were not noticed till the next day. The four measurements when reduced gave a probable error of .0115′, or about 1 in 1,040,000, the length of the base being 11,999.89′.

The running water base was fully as good a location as either of the other bases; but, for some reason not easily accounted for, the results did not compare well, and five measurements were made of the south part and six of the north part of the base. All the measurements were used, and the probable error of the north part of the base was quite small, being only .005′, but for the south and longer part of the base the probable error was .042′, or an accuracy of only about 1 in 264,000. This measurement was made in October, and the temperature during both night and day measurements for this base was quite fluctuating, with distinct cold currents of air. This might, in a measure, account for the wide range in results.

The reductions of these base lines are given below in tabulated form as reduced.

Very respectfully, your obedient servant,

G. A. MARR,
Assistant Engineer.

First Lieut. J. C. SANFORD,
Corps of Engineers, U. S. A.
Secretary Missouri River Commission.

BISMARCK BASE.

Temperatures during measurements.

No. of tape.	First measurement.				Second measurement.				Third measurement.			Fourth measurement.		
	April 6, 1889. P. M.	Thermometers.			April 8, 1889. P. M.	Thermometers.			April 15, 1889. P. M.	Thermometers.		April 16, 1888. A. M.	Thermometers.	
		5101	5103	5107		5101	5103	5107		5100	5107		5100	5107
	h. m.	°	°	°	*h. m.*	°	°	°	*h. m.*	°	°	*h. m.*	°	°
1	8 37	55.8	55.0	55.9	8 44	35.9	37.0	39.6	2 52	60.6	61.0	10 03	45.0	44.9
2	.....	54.8	54.1	55.0	.....	36.0	36.5	36.4	2 58	58.5	59.0	.....	44.1	44.4
3	.....	54.0	54.1	54.1	8 51	34.1	34.1	35.2	.....	58.1	58.5	.....	43.3	43.9
4	.....	53.6	53.1	53.0	.....	34.1	34.0	34.6	.....	58.5	58.7	.....	43.6	43.5
5	9 02	52.7	53.0	52.4	.....	36.8	34.1	33.5	.....	59.4	58.2	.....	43.2	43.0
6	.....	51.7	52.1	51.6	.....	35.8	35.6	36.0	.....	58.9	58.5	.....	43.6	43.1
7	.....	52.8	52.0	50.6	9 10	33.4	35.4	34.6	3 10	58.4	58.7	10 15	43.6	43.1
8	9 15	51.1	51.0	51.3	.....	35.4	35.2	34.4	.....	59.2	59.4	.....	43.5	43.5
9	.....	51.8	51.1	50.9	.....	35.0	33.8	35.1	.....	60.9	59.7	.....	43.5	43.1
10	.....	51.4	51.0	51.0	.....	34.8	35.0	34.8	.....	60.0	59.0	10 20	44.0	43.9
11	.....	50.9	50.1	51.2	.....	35.3	35.9	35.6	.....	59.2	59.4	.....	44.0	43.9
12	9 28	51.6	51.1	52.0	9 24	36.4	36.2	35.3	3 22	59.0	58.6	.....	43.9	43.6
13	.....	51.4	51.0	51.6	.....	34.8	35.6	36.8	.....	58.5	58.7	.....	44.9	44.0
14	.....	51.4	51.1	52 0	.....	31.6	31.5	33.7	.....	59.2	59.4	.....	45.6	44.3
15	.....	51.8	52.0	51.6	.....	31.1	31.1	31.2	.....	59.0	59.0	10 30	45.6	44.9
16	9 40	52.0	52.1	52.2	.....	31.4	31.5	31.0	.....	58.7	59.2	.....	46.5	46.3
17	.....	52.1	52.1	52.2	.....	33.5	33.5	30.5	.....	58.5	59.3	10 36	46.5	45.5
18	.....	52.1	53.0	52.3	.....	29.4	32.4	31.8	3 35	59.0	59.5	10 45	47.8	47.6
19	.....	52.0	52.1	52.4	.....	31.0	29.5	29.5	.....	59.9	60.4	.....	47.8	47.1
20	.....	52.4	52.0	51.8	9 45	31.7	31.4	32.0	.....	59.5	59.5	.....	47.4	46.4
21	9 57	52.1	52.0	51.9	9 49	28.0	31.4	35.1	.....	60.1	59.3	10 51	48.9	47.5
22	.....	53.0	53.0	53.2	9 55	31.6	30.5	28.8	.....	59.3	59.4	.....	49.3	47.6
23	.....	53.2	53.1	53.7	.....	28 9	27.5	31.0	.....	59.2	59.2	10 55	51.3	50.0
24	.....	53.1	53.0	53.1	.....	29.5	30.6	28.7	3 46	59.2	58.7	11 00	50.1	49.0
25	10 09	53.0	52.1	53.3	.....	29.3	30.4	29.6	.....	58.1	58.7	.....	51.7	50.4
26	.....	52.8	52.1	53.0	.....	26.8	28.1	30.6	.....	58.4	58.7	11 05	52.1	52.4
27	.....	52.0	52.0	52.0	10 12	24.4	25.6	28.6	.....	59.0	58.8	.....	54.2	52.4
28	.....	51.6	52.0	51.9	.....	26.6	25.0	25.9	.....	58.9	58.6	11 15	54.8	55.0
29	10 21	51.0	51.1	50.7	.....	29.5	28.0	29.3	3 54	59.0	58.9	.....	55.3	55.2
30	.....	51.5	52.0	52.2	.....	31.2	32.0	32.1	.....	59.6	59.0	.....	56.7	53.7
31	.....	51.6	52.1	52.8	.....	32.1	31.9	32.2	.....	60.2	60.1	11 20	53.0	52.4
32	.....	52.4	52.1	52.7	.....	32.7	31.5	32.0	.....	60.1	60.0	.....	53.1	52.8
33	10 33	52.5	52.0	52.2	10 26	32.7	32.2	32.6	4.04	60.5	61.1	.....	55.6	54.2
34	.....	52.1	52.0	52.2	.....	32.4	33.2	31.9	.....	61.0	60.1	11 26	56.0	55.8
35	.....	52.4	52.0	52.3	10 37	31.4	30.2	30.0	.....	61.0	59.6	.....	54.7	53.2
36	.....	52.4	52.1	52.2	.....	31.5	31.5	30.1	.....	59.6	59.4	.....	56.9	54.0
37	.....	52.5	52.0	52.7	.....	31.4	30.4	31.0	.....	59.0	59.3	11.36	54.3	55.9
38	.....	52.1	52.0	52.1	.....	31.3	30.6	28.7	4 19	58.9	58.5	.....	56.0	54.3
39	.....	52.3	52.1	52.2	.....	31.4	29.0	28.4	.....	58.3	58.8	.....	54.2	56.6
40	10 52	52.2	52.5	52.4	.....	29.5	28.1	29.1	.....	58.2	59.0	11 43	57.0	55.6
41	.....	52.6	52.6	52.3	10 55	31.0	29.5	30.7	.....	58.5	58.7	.....	58.1	55.0
42	.....	52.1	52.5	51.9	.....	31.4	31.6	33.0	.....	58.1	58.3	.....	55.3	55.7
43	.....	52.1	52.4	52.2	.....	31.4	31.2	31.3	4 31	58.4	58.3	.....	56.0	55.8
44	.....	52.1	51.9	52.3	.....	31.7	29.7	30.0	.....	58.8	58.8	11 52	57.1	57.5
45	11 09	52.3	52.0	51.3	.....	30.8	30.2	29.9	.....	58.8	58.1	.....	55.7	54.9
46	.....	51.9	52.0	51.7	11 06	33.7	33.9	32.8	4 40	58.3	58.2	11 56	58.5	57.9
47	.....	52.6	51.1	51.6	.....	34.0	32.4	33.5	.....	58.1	58.2	.....	54.0	54.9
48	.....	52.0	52.0	51.7	.....	34.8	34.9	33.7	.....	58.1	58.2	.....	54.1	53.9
49	.....	52.1	51.6	52.0	.....	34.1	35.3	34.9	.....	58.0	57.7	12 02	54.5	55.5
50	11 27	51.7	51.5	51.7	.....	35.4	35.1	35.7	.....	58.8	58.1	.....	54.3	54.5
51	.....	51.6	51.4	51.1	11 23	35.3	34.7	34.0	4 50	58.0	57.9	.....	56.2	54.5
52	.....	51.5	51.0	51.3	.....	34.6	34.0	34.2	.....	58.5	57.7	.....	54.9	54.8
53	11 39	51.5	51.0	51.7	.....	33.9	34.0	34.2	.....	58.1	58.2	.....	55.4	54.5
54	.....	50.7	50.5	51.1	.....	33.8	33.6	32.4	.....	58.4	58.8	.....	54.5	57.9
55	.....	50.5	50.4	50.3	11 33	31.4	32.0	32.4	5 03	58.6	58.0	12 15	55.4	55.4
55½	.....	49.8	49.55	49.8	11 46	31.5	31.35	28.8	5 10	58.1	58.5	12 22	58.5	57.9
	Means	52.15	51.96	52.09	.....	32.29	32.15	32.30	.....	58.94	58.99	.....	51.16	50.69
		Means of all		52.07			32.25			58.96			50.925	
							Cor.=+0.07			Cor.=+0.05			Cor.=+0.05	
								32.32			59.01			50.975

Bismarck base—correction for inclination (i) of tape.

[Sin. $i = \frac{h}{l}$ Correction $= l \times$ ver. sin. $i = l \times 2$ sin.$^2 \frac{1}{2}$i. $l = 300'.02398$ = length of tape.]

No. of stake.	Elevation.	Difference of elevation = h.	Log. h.	Log. sin. i.	i.	Log. sin. $\frac{1}{2}i$.	Log. sin.$^2 \frac{1}{2}i$.	Log. 1 + log. ver. sin. i = log. 2 l + log. sin.$^2 \frac{1}{2}i$.	Correction.
	′	′			° ′ ″				′
S. base	6.300								
1	*0.000	6.300	0.79934	8.32218	1 12 11	8.02112	6.04224	8.82043	0.06613
2	1.548	1.548	0.18977	7.71261	17 44	7.41149	4.82298	7.60117	0.00399
3	0.794	.754	9.87737	7.40021	8 38	7.09887	4.19774	6.97593	0.00095
4	0.970	.176	9.24551	6.76835	2 1	6.46732	2.93464	5.71283	0.00005
5	1.180	.210	9.32222	6.84506	2 24	6.54291	3.08582	5.86401	0.00007
6	1.201	.021	8.32222	5.84506	0 14	5.53067	1.06134	3.83953	0.00000
7	1.238	.037	8.56820	6.09104	0 25	5.78214	1.56428	4.34247	0.00000
8	1.785	.547	9.73799	7.26083	6 16	6.95973	3.91946	6.69765	0.00050
9	0.463	1.322	0.12123	7.64407	15 9	7.34311	4.68622	7.46441	0.00291
10	0.730	.267	9.42651	6.94935	3 4	6.64936	3.29872	6.07691	0.00012
11	1.079	.349	9.54283	7.06567	4 0	6.76476	3.52952	6.30771	0.00020
12	1.489	.410	9.61278	7.13562	4 42	6.83479	3.66958	6.44777	0.00028
13	1.327	.162	9.20951	6.73235	1 51	6.42985	2.85970	5.63789	0.00004
14	1.939	.612	9.78675	7.30959	7 1	7.00883	4.01766	6.79585	0.00062
15	3.618	1.679	0.22505	7.74789	19 14	7.44675	4.89350	7.67169	0.00470
16	3.476	.142	9.15229	6.67513	1 38	6.35777	2.75154	5.52973	0.00003
17	4.008	.532	9.72591	7.24875	6 6	6.94803	3.89606	6.67425	0.00047
18	3.486	.522	9.71767	7.24051	5 59	6.93964	3.87928	6.65747	0.00045
19	3.760	.274	9.43775	6.96059	3 8	6.65870	3.31740	6.09559	0.00012
20	3.541	.219	9.34044	6.86328	2 31	6.56351	3.12702	5.90521	0.00008
21	3.317	.224	9.35025	6.87309	2 34	6.57207	3.14414	5.92233	0.00008
22	4.058	.741	9.86982	7.39266	8 29	7.09126	4.18252	6.96071	0.00091
23	4.306	.248	9.39445	6.91729	2 50	6.61499	3.22998	6.00817	0.00010
24	4.159	.147	9.16732	6.69016	1 41	6.38884	2.77768	5.55587	0.00004
25	4.198	.039	8.59106	6.11390	0 27	5.81561	1.63122	4.40941	0,00000
26	4.286	.088	8.94448	6.46732	1 01	6.16982	2.33964	5.11783	0.00001
27	3.901	.385	9.58546	7.10830	4 25	6.80779	3.61558	6.39377	0.00025
28	4.542	.641	9.80686	7.32970	7 21	7.02898	4.05796	6.83615	0.00069
29	5.012	.470	9.67210	7.19494	5 23	6.89375	3.78750	6.56569	0.00037
30	4.788	.224	9.35025	6.87309	2 34	6.57207	3.14414	5.92233	0.00008
31	5.010	.222	9.34635	6.86919	2 33	6.56923	3.13846	5.91665	0.00008
32	5.722	.712	9.85248	7.37532	8 09	7.07385	4.14770	6.92589	0.00084
33	5.566	.156	9.19312	6.71596	1 47	6.41391	2.82782	5.60601	0.00004
34	4.569	.997	9.99870	7.52154	11 25	7.22023	4.44046	7.21865	0.00166
35	4.677	.108	9.03342	6.55626	1 14	6.25378	2.50756	5.28575	0.00002
36	4.443	.234	9.36922	6.89206	2 41	6.59136	3.18272	5.96091	0.00009
37	4.311	.132	9.12057	6.64341	1 31	6.34356	2.68712	5.46531	0.00003
38	4.497	.186	9.26951	6.79235	2 08	6.49175	2.98350	5.76169	0.00006
39	4.938	.441	9.64444	7.16728	5 03	6.86599	3.73198	6.51017	0.00032
40	4.358	.580	9.76343	7.28627	6 39	6.98552	3.97104	6.74923	0.00056
41	4.698	.340	9.53148	7.05432	3 54	6.75376	3.50752	6.28571	0.00019
42	4.439	.259	9.41330	6.93614	2 58	6.63496	3.26992	6.04811	0.00011
43	4.119	.320	9.50515	7.02799	3 40	6.72697	3.45394	6.23213	0.00017
44	5.113	.994	9.99739	7.52023	11 23	7.21896	4.43792	7.21611	0.00164
45	5.340	.227	9.35603	6.87887	2 36	6.57767	3.15534	5.93353	0.00009
46	5.152	.188	9.27416	6.79700	2 09	6.49512	2.99024	5.76843	0.00006
47	5.158	.006	7.77815	5.30099	0 04	4.98660	9.97320	2.75139	0.00000
48	6.552	1.394	0.14426	7.66710	15 58	7.36591	4.73182	7.51001	0.00324
49	6.291	.261	9.41664	6.93948	2 59	6.63739	3.27478	6.05297	0.00011
50	6.394	.103	9.01284	6.53568	1 11	6.23576	2.47152	5.24971	0.00002
51	6.560	.166	9.22011	6.74295	1 54	6.44145	2.88290	5.66109	0.00005
52	4.523	2.037	0.30899	7.83183	23 20	7.53067	5.06134	7.83953	0.00691
53	6.529	2.006	0.30233	7.82517	22 59	7.52411	5.04822	7.82641	0.00671
54	6.775	.246	9.39094	6.91378	2 49	6.61242	3.22484	6.00303	0.00010
55	5.871	.904	9.95617	7.47901	10 21	7.17764	4.35528	7.13347	0.00136
55½ or N. base	6.037	.166	9.22011	6.74295	1 54	6.44145	2.88290	5.66109	0.00005
								Total correction for inclination of tape =	0′.10875

* Stake 1 assumed as zero, it being the lowest point.

16′.947 = elevation of △ N. base above water-surface opposite.
−04.6 = water-surface at bridge gauge above water-surface opposite △ N. base.

16.347 = elevation of △ N. base above water-surface at bridge gauge.
1619.95 = gauge record, April 8, 1889, above sea-level (see note-book).

1636.297 = elevation of △ N. base above sea-level.
−2.105 = mean elevation of base below △ N. base.

1634.192 = mean elevation of base above sea-level.

Correction to reduce to sea-level.

$\delta = \frac{Ba}{N}$. (See Lee's tables, page 84.)

Log B = log 16650′.85114 = 4.2214364
Log A = log 1634.192 = 3.2133031

7.4347395
Log N = (at lat. 46° 48½′) = 7.3214082
Log S = 0 1133313
Hence correction = −1′.29817

Bismarck base.

Four measurements expressed by the following equations:

(First) [55½×300′.02398] −1′.14255 +1′.00000 −0′.10875 = 16651′.07959*
(Second) [55½×300′.02398] −3′.41500 +2′.29583 +0′.70375 −0′.10875 = 16650′.80672
(Third) [55½×300′.02398] −0′.34403 +0′.04625 −0′.10875 = 16650′.92436
(Fourth) [55½×300′.02398] −1′.26854 +0′.83333 +0′.03542 −0′.10875 = 16650′.82235

Mean, four measurements = 16650′.90825

Second, third, and fourth measurements, mean = 16650′.85114

First term is number of tapes into length of tape at 62° Fahr. under 16 pounds tension.
Second term is temperature correction to 62° Fahr.
Third term is distance set forward on zincs.
Fourth term is distance between end of last tape and △ N. base.
Fifth term is correction for inclination of tape.
The second member is the corrected independent result for each measurement.

The mean of three measurements = 16650′.85114
Correction to reduce to sea-level = −1′.29817

Bismarck base reduced to sea-level = 16649′.55297
Accuracy about 1 in 666,000.

NOTE.—The ½ tape was measured by using both halves of tape and taking mean.

* The first measurement is rejected on account of uncertainties in regard to supports for tape being disturbed before the marks were made, and also that it was practice for many of the party engaged on the work.

BISMARCK BASE.

Measured differences on zincs.

Tape.	Measurements.					
	2d–1st.	3d–1st.	4th–1st.	3d–2d.	3d–4th.	4th–2d.
	"	"	"	"	"	"
1....	— 0.375	+ 0.21	— 0.195	+ 0.585	+ 0.405	+ 0.18
2....	— 0.72	+ 0.36	— 0.325	+ 1.08	+ 0.685	+ 0.395
3....	— 1.16	+ 0.46	— 0.58	+ 1.62	+ 1.04	+ 0.58
4....	— 1.61	+ 0.55	— 0.82	+ 2.16	+ 1.37	+ 0.79
5....	— 1.98	+ 0.75	— 1.005	+ 2.73	+ 1.755	+ 0.975
6....	— 2.19	+ 1.07	— 1.05	+ 3.26	+ 2.12	+ 1.14
7....	+ 2.145	+ 1.25	— 1.23	— 0.89	+ 2.48	+ 3.375
8....	+ 1.80	+ 1.50	— 1.36	— 0.30	+ 2.86	— 3.16
9....	+ 1.48	+ 1.79	— 1.50	+ 0.31	+ 3.29	— 2.98
10....	+ 1.14	+ 1.94	— 1.75	+ 0.80	+ 3.69	— 2.89
11....	+ 0.87	+ 2.29	— 1.81	+ 1.42	+ 4.10	— 2.68
12....	+ 0.50	+ 2.50	— 2.00	+ 2.00	+ 4.50	— 2.50
13....	+ 0.20	+ 2.70	— 2.13	+ 2.50	+ 4.83	— 2.33
14....	— 0.25	+ 2.93	— 2.21	+ 3.18	+ 5.14	— 1.96
15....	— 0.74	+ 3.08	— 2.36	+ 3.82	+ 5.44	— 1.62
16....	— 1.18	+ 3.26	— 2.47	+ 4.44	+ 5.73	— 1.29
17....	— 1.62	+ 3.42	— 2.61	+ 5.04	+ 6.03	— 0.99
18....	— 2.05	+ 3.60	— 2.67	+ 5.65	+ 6.27	— 0.62
19....	— 2.50	+ 3.86	— 2.70	+ 6.36	+ 6.56	— 0.20
20....	— 3.00	+ 4.07	— 2.81	+ 7.07	+ 6.88	— 0.19
21....	— 3.44	+ 4.33	— 2.84	+ 7.77	+ 7.17	+ 0.60
22....	+ 4.26	+ 4.52	— 2.87	+ 0.26	+ 7.39	+ 7.13
23....	+ 3.69	+ 4.65	— 2.90	+ 0.96	+ 7.55	— 6.59
24....	+ 3.14	+ 4.79	— 3.00	+ 1.65	+ 7.79	— 6.14
25....	+ 2.61	+ 4.94	— 3.02	+ 2.33	+ 7.96	— 5.63
26....	+ 2.10	+ 5.18	— 2.92	+ 3.08	+ 8.10	— 5.02
	+4.715			−0.385		−7.555
	Set ahead = +8″.155 in 2d M.			Set ahead = +6″.155 in 2d M.		
	+2.515		+7.20	−1.445	−1.83	−3.565
	Set ahead = +4″.705 in 2d M.		Set ahead = +10″.00 in 4th M.	Set ahead = +4″.705 in 2d M.	Set ahead = +10″.00 in 4th M.	
27....	+ 1.46	+ 5.37	— 2.80	+ 3.91	+ 8.17	— 4.26
28....	+ 0.91	+ 5.64	+ 7.40	+ 4.73	— 1.76	+ 6.49
29....	+ 0.39	+ 5.89	+ 7.61	+ 5.50	— 1.72	+ 7.22
30....	— 0.07	+ 6.10	+ 7.71	+ 6.17	— 1.61	+ 7.78
31....	— 0.48	+ 6.34	+ 7.80	+ 6.82	— 1.46	+ 8.28
32....	— 0.90	+ 6.62	+ 7.93	+ 7.52	— 1.31	+ 8.83
33....	— 1.40	+ 6.86	+ 8.08	+ 8.26	— 1.22	+ 9.48
	+12.89			−5.71		−4.59
	Set ahead = +14″.69			Set ahead = +14″.69		Set ahead = +10″.00 4th M.
34....	— 1.80	+ 7.18	+ 8.30	+ 8.98	— 1.12	+10.10
35....	+12.46	+ 7.56	+ 8.44	— 4.90	— 0.88	— 4.02
36....	+11.97	+ 7.76	+ 8.49	— 4.21	— 0.73	— 3.48
37....	+11.53	+ 8.02	+ 8.74	— 3.51	— 0.72	— 2.79
38....	+11.02	+ 8.17	+ 8.87	— 2.85	— 0.70	— 2.15
39....	+10.52	+ 8.37	+ 9.07	— 2.15	— 0.70	— 1.45
40....	+ 9.97	+ 8.52	+ 9.22	— 1.45	— 0.70	— 0.75
41....	+ 9.50	+ 8.72	+ 9.38	— 0.78	— 0.66	— 0.12
42....	+ 8.99	+ 8.81	+ 9.49	— 0.18	— 0.68	+ 0.50
43....	+ 8.57	+ 8.98	+ 9.73	+ 0.41	— 0.75	+ 1.16
44....	+ 8.09	+ 9.17	+ 9.93	+ 1.08	— 0.76	+ 1.84
45....	+ 7.68	+ 9.45	+10.13	+ 1.77	— 0.68	+ 2.45
46....	+ 7.24	+ 9.55	+10.20	+ 2.31	— 0.65	+ 2.96
47....	+ 6.89	+ 9.81	+10.37	+ 2.92	— 0.56	+ 3.48
48....	+ 6.56	+ 9.98	+10.43	+ 3.42	— 0.45	+ 3.87
49....	+ 6.23	+10.19	+10.60	+ 3.96	— 0.41	+ 4.37
50....	+ 5.83	+10.36	+10.68	+ 4.53	— 0.32	+ 4.85
51....	+ 5.44	+10.53	+10.85	+ 5.09	— 0.32	+ 5.41
52....	+ 4.97	+10.64	+10.88	+ 5.67	— 0.24	+ 5.91
23....	+ 4.58	+10.84	+11.00	+ 6.26	— 0.16	+ 6.42
54....	+ 4.18	+11.00	+11.14	+ 6.82	— 0.14	+ 6.96
55....	+ 3.79	+11.28	+11.36	+ 7.49	— 0.08	+ 7.57
55½...	+ 3.56	+11.45	+11.58	+ 7.89	— 0.13	+ 8.02

End of first measurement back, or south of △ north base = 12″.000 = 1′.00000.
End of second measurement back, or south of △ north base = 8″.445 = 0′.70375.
End of third measurement back, or south of △ north base = 0″.555 = 0′.04625.
End of fourth measurement back, or south of △ north base = 0″.425 = 0′.03542.

PIERRE BASE.

Temperatures during measurements.

No. of tape.	First measurement.			Second measurement.			Third measurement.			Fourth measurement.			Fifth measurement.		
	July 20, 1889, p. m.	Thermometers.		July 21, 1889, p. m.	Thermometers.		July 22, 1889, p. m.	Thermometers.		July 22, 1889, p. m.	Thermometers.		July 24, 1889, a. m.	Thermometers.	
		5100.	5107.		5100.	5107.		5100.	5107.		5100.	5107.		5100.	5107.
	H. M.	°	°	*H. M.*	°	°	*H. M.*	°	°	*H. M.*	°	°	*H. M.*	°	°
1	9 18	74.3	73.5	4 57	73.8	73.9	2 27	67.2	67.1	5 14	61.5	62.8	8 03	67.5	67.5
2	.....	75.6	74.3	.....	73.8	73.2	.....	67.5	67.6	.....	62.0	62.6	8 10	67.6	67.8
3	.....	75.0	75.0	.....	73.1	73.0	.....	67.8	67.5	.....	62.0	62.6	.....	67.8	68.0
4	.....	75.5	75.0	.....	71.5	71.3	.....	69.2	67.5	.....	61.8	63.1	.....	68.0	68.1
5	9 34	75.6	75.0	.....	71.0	71.0	2 37	68.8	68.0	5 23	62.0	62.9	8 24	68.2	68.4
6	.....	76.0	75.6	.....	73.2	74.0	.....	68.4	67.7	.....	62.0	62.5	.....	68.5	68.6
7	.....	76.5	76.0	.....	73.5	73.2	.....	67.8	67.5	.....	62.0	62.7	.....	68.5	68.6
8	.....	76.1	75.7	.....	74.8	74.2	.....	67.0	67.6	.....	62.0	63.0	8 38	68.4	68.5
9	.....	76.6	76.3	5 20	72.5	72.5	2 45	67.0	67.1	.....	62.2	63.0	.....	68.5	68.6
10	9 49	75.5	75.6	5 27	71.8	71.8	.....	66.6	66.0	.....	62.0	63.3	.....	68.6	68.6
11	.....	77.0	76.2	.....	71.0	71.0	.....	65.5	66.5	5 35	62.3	63.2	.....	68.7	69.1
12	.....	77.0	76.2	.....	71.6	72 1	.....	66.0	66.0	.....	62.3	63.4	.....	69.1	69.3
13	.....	77.0	77.0	.....	72.8	72.2	.....	65.5	65.6	5 46	62.8	63.4	.....	69.6	69.6
14	.....	77.2	77.7	5 35	73.0	74.0	.....	65.5	65.5	.....	62.5	63.5	.....	70.0	70.1
15	.....	77.5	77.1	.....	72.8	72.8	3 06	65.8	65.5	.....	63.1	63.6	.....	70.2	70.1
16	10 10	77.4	77.6	.....	72.6	72.6	.....	65.5	65.5	.....	63.5	64.0	.....	70.5	69.8
17	.....	77.0	77.1	5 42	74.0	74.7	.....	65.6	65.3	.....	63.1	64.4	9 10	71.6	72.0
18	.....	77.7	77.6	.....	74.0	74.7	.....	66.0	65.5	.....	63.2	64.2	9 17	71.5	72.0
19	.....	77.0	77.1	.....	73.6	74.4	.....	65.5	65.5	6 01	63.2	64.0	.....	72.0	71.5
20	10 26	76.5	76.8	5 49	73.0	73.5	3 17	66.2	65.4	.....	64.0	64.8	.....	72.0	71.9
21	.....	76.1	76.2	5 55	72.2	72.5	.....	66.1	65.6	6 06	64.5	65.0	9 31	73.0	73.0
22	10 39	76.0	76.7	.....	72.6	73.4	.....	65.6	65.5	6 17	66.8	66.8	.....	73.6	73.5
23	.....	76.5	76.0	.....	73.8	73.6	.....	66.2	66.5	.....	66.1	66.5	.....	73.8	73.6
24	.....	76.0	75.5	.....	73.8	74.5	.....	66.2	66.1	.....	65.5	65.4	.....	73.6	74.0
25	10 48	76.0	76.0	6 10	74.2	73.8	3 30	66.0	65.9	.....	65.1	65.4	.....	74.0	73.8
26	.....	76.0	76.2	.....	73.0	74.0	.....	66.1	66.4	.....	66.0	66.0	.....	73.8	73.9
27	.....	75.8	75.8	.....	73.0	73.2	.....	66.0	66.5	.....	65.8	66.0	.....	73.8	73.8
28	.....	76.0	75.7	6 18	73.2	73.2	.....	66.0	66.1	.....	65.5	65.9	.....	73.8	73.6
29	11 00	76.6	76.3	.....	72.6	72.5	.....	65.6	65.9	6 37	65.0	65.0	9 49	74.0	74.0
30	.....	76.4	76.2	.....	71.5	71.5	.....	65.5	65.8	.....	64.6	64.4	.....	74.0	74.1
31	.....	76.2	76.5	.....	71.8	71.5	3 42	65.5	65.6	.....	64.6	64.6	.....	74.5	74.5
32	.....	76.0	76.1	6 27	71.0	71.0	.....	65.1	65.4	.....	65.0	65.4	9 54	75.8	76.4
33	.....	76.2	76.5	6 49	70.0	69.8	.....	65.0	65.0	.....	64.5	65.0	.....	75.0	76.3
34	11 12	75.8	76.0	.....	69.6	69.5	.....	65.0	65.0	6 48	64.0	64.2	.....	75.4	76.0
35	.....	75.0	75.4	.....	69.5	69.5	3 51	64.6	65.0	.....	63.4	63.6	.....	75.6	75.9
36	.....	74.8	75.2	.....	69.5	69.4	.....	64.5	64.5	.....	63.0	64.0	.....	75.6	75.5
37	11 20	73.5	73.6	6 57	69.8	69.7	.....	64 2	64.2	.....	62.6	63.4	.....	75.5	75.7
38	.....	73.0	72.2	.....	70.2	70.2	.....	64.0	64.2	.....	62.6	63.0	10 05	76.0	75.8
39	.....	73.0	72.2	.....	70.6	71.0	.....	64.2	64.0	.....	62.5	62.9	.....	76.4	76.0
40	11 33	73.2	72.2	7 04	72.4	72.3	4 04	64.2	64.2	7 02	62.5	62.8	10 10	76.0	75.9
Means for each thermometer ...		75.90	75.72	.....	72.2925	72.405	.....	66.025	65.92	.....	63.4775	64.0575	.....	72.00	72.085
Means for each measurement ...		75°.81		.....	72°.35		.....	65°.9725		.....	63°.7675		.....	72°.0425	
Corrections ..		0 .00		.....	0 .00		.....	+0 .0375		.....	+0 .0425		.....	0 .00	
Corrected means		75°.81		.....	72°.35		.....	66°.01		.....	63°.81		.....	72°.04	

PIERRE BASE.

Correction for inclination (i) of tape.

[Sin $i = \frac{h}{l}$ Correction $= l \times$ ver sin $i = l \times 2 \sin^2 \frac{1}{2} i$. $l = 300'.02398$ = length of tape No. III.]

No. of stake.	Elevation.	Diff. of elevation $= h$.	Log. h.	Log. sin i = log. h − log. l.	i.*	Log. sin $\frac{1}{2} i$.	Log. $\sin^2 \frac{1}{2} i$.	Log. l + log. ver sin i. Log. $2l$ + log. $\sin^2 \frac{1}{2} i$.	Correction.
	′	′			° ′ ″				′
W. base	5.837								
1	3.752	2.085	0.31911	7.84195	0 23 54	7.54109	5.08218	7.86037	0.00725
2	3.655	0.097	8.98677	6.50961	1 06	6.20409	2.40818	5.18637	0.00002
3	3.563	.092	8.96379	6.48663	1 04	6.19072	2.38144	5.15963	0.00001
4	3.304	.259	9.41380	6.93614	2 58	6.63496	3.26992	6.04811	0.00011
5	2.323	.981	9.99167	7.51451	11 14	7.21320	4.42640	7.20459	0.00160
6	2.237	.086	8.93450	6.45734	1 00	6.16270	2.32540	5.10359	0.00001
7	1.928	.309	9.48996	7.01280	3 32	6.71088	3.42176	6.19995	0.00016
8	1.776	.152	9.18184	6.70468	1 44	6.40158	2.80316	5.58135	0.00004
9	1.381	.395	9.59660	7.11944	4 32	6.81911	3.63822	6.41641	0.00026
10	1.111	.270	9.43136	6.95420	3 06	6.65406	3.30812	6.08631	0.00012
11	0.466	.645	9.80956	7.33240	7 24	7.03193	4.06386	6.84205	0.00070
12†	0.000	.466	9.66839	7.19123	5 20	6.88969	3.77938	6.55757	0.00036
13	1.928	1.928	0.28511	7.80795	22 06	7.50709	5.01418	7.79237	0.00620
14	5.165	3.237	0.51014	8.03298	37 06	7.73207	5.46414	8.24233	0.01747
15	4.331	.834	9.92117	7.44401	9 34	7.14346	4.28692	7.06511	0.00116
16	4.919	.588	9.76938	7.29222	6 44	6.99093	3.98186	6.76005	0.00058
17	5.408	.489	9.68931	7.21215	5 36	6.91088	3.82176	6.59995	0.00040
18	6.594	1.186	0.07408	7.59692	13 36	7.29623	4.59246	7.37065	0.00235
19	8.715	2.121	0.32654	7.84938	24 18	7.54830	5.09660	7.87479	0.00750
20	9.548	.833	9.92064	7.44348	9 32	7.14194	4.28388	7.06207	0.00115
21	7.242	2.306	0.36286	7.88570	26 26	7.58485	5.16970	7.94789	0.00887
22	6.616	.626	9.79657	7.31941	7 10	7.01801	4.03602	6.81421	0.00065
23	5.920	.696	9.84261	7.36545	7 58	7.06397	4.12794	6.90613	0.00081
24	5.397	.523	9.71850	7.24134	6 00	6.94085	3.88170	6.65989	0.00046
25	4.937	.460	9.66276	7.18560	5 16	6.88423	3.76846	6.54665	0.00035
26	4.844	.093	8.96848	6.49132	1 04	6.19072	2.38144	5.15963	0.00001
27	4.829	.015	8.17609	5.69893	0 10	5.38454	0.76908	3.54727	0.00000
28	5.033	.204	9.30963	6.83247	2 20	6.53067	3.06134	5.83953	0.00007
29	4.564	.469	9.67117	7.19401	5 22	6.89240	3.78480	6.56299	0.00037
30	4.695	.131	9.11727	6.64011	1 30	6.33879	2.67758	5.45577	0.00003
31	4.329	.366	9.56348	7.04632	4 12	6.78595	3.57190	6.35009	0.00022
32	4.573	.244	9.38739	6.91023	2 48	6.60985	3.21970	5.99789	0.00010
33	5.767	1.194	0.07700	7.58984	13 40	7.29836	4.59672	7.37491	0.00037
34	5.894	.127	9.10380	6.62664	1 28	6.32903	2.65806	5.43625	0.00003
35	6.418	.524	9.71933	7.24217	6 00	6.94085	3.88170	6.65989	0.00046
36	6.811	.393	9.59439	7.11723	4 30	6.81591	3.63182	6.41001	0.00026
37	7.405	.594	9.77379	7.29663	6 48	6.99520	3.99040	6.76859	0.00069
38	8.437	1.032	0.01368	7.53652	11 50	7.23580	4.47160	7.24979	0.00178
39	8.954	.517	9.71349	7.23633	5 56	6.93599	3.87198	6.65017	0.00045
40 △ E. base	8.921	.033	8.51851	6.04135	0 22	5.72697	1.45394	4.23213	0.00000
	199′.527 / 41 = 4′.867				Total correction for inclination				0.06533

* On account of using half this angle the nearest even second is taken.
† Stake 12 taken as zero, it being the lowest point.

Hence 4′.867 = mean elevation of base above lowest point.

1017′.933 = elevation of △ W. base above St. Louis City directrix.
412′.71 = elevation of St. Louis City directrix above sea-level.
1430′.643 = elevation of △ W. base above sea-level.
0′.970 = elevation of △ W. base above mean elevation of base.
1429′.673 = mean elevation of Pierre base above sea-level.

Correction to reduce to sea-level:

$\delta = \frac{Ba}{N}$ (See Lee's tables, page 84.)

Log. B	= log. 12000′.71331	= 4.0792070
Log. a	= log. 1429′.673	= 3.1552367
		7.2344437
Log. N. (at lat. 44° 20′)		= 7.3213453
Log. correction		= 9.9130984
Hence correction		= 0′.81865

Five measurements expressed by the following equations:

(First)	[40 × 300.02398] + 1.14526 − 1.16917 − 0.01667 − 0.06533	= 12000.85329*
(Second)	[40 × 300.02398] + 0.85833 − 0.31667 − 0.67583 − 0.06533	= 12000.75970
(Third)	[40 × 300.02398] × 0.33255 + − 0.50833 − 0.06533	= 12000.71809
(Fourth)	[40 × 300.02398] − 0.15010 − 0.16583 − 0.51667 − 0.06533	= 12000.69313
(Fifth)	[40 × 300.02398] × 0.83262 − 0.19167 − 0.85250 − 0.06533	= 12000.68232
	Five measurements, mean	= 12000.74131
	Second, third, fourth, and fifth mean	= 12000.71331

First term is number of tapes into length of tape at 62° Fahrenheit.
Second term is temperature correction.
Third term is distance set back or forward on zincs.
Fourth term is distance between end of last tape and △ E. base.
Fifth term is correction for inclination of tape.
The second member is the corrected independent result for each measurement.
The mean of four measurements = 12000′.71331 ± 0′.0115
Correction to reduce to sea-level = —0.81865

Pierre base reduced to sea-level = 11999.89466
Accuracy about 1 in 1,040,000.

PIERRE BASE.

Measured differences on zincs.

Tape.	Measurements.					
	2d–1st.	2d–3d.	2d–4th.	2d–5th.	3d–4th.	3d–5th.
	″	″	″	″	″	″
1	+0.05	+0.17	+0.30	+0.16	+0.13	—0.01
2	0.05	0.28	0.53	0.30	0.25	+0.02
3	0.05	0.36	0.78	0.44	0.42	0.08
4	—0.04	+0.38	0.96	+0.46	+0.58	+0.08
5	0.12	0.45	1.17	0.55	0.72	0.10
6	0.12	0.56	1.44	0.65	0.88	0.09
7	0.16	0.72	1.74	0.80	1.02	0.08
8	0.16	0.89	2.00	0.94	1.11	0.05
9	0.21	1.00	2.20	1.07	1.20	+0.07
10	0.30	1.10	2.38	1.08	1.28	—0.02
11	0.42	1.22	2.55	1.12	1.33	0.10
12	0.50	1.36	2.77	1.20	+1.41	0.16
13	0.58	1.55	1.00	1.27	—0.55	0.28
14	—0.64	+1.72	1.23	+1.30	—0.50	—0.42
15	0.72	1.91	1.42	1.37	0.49	0.54
16	0.80	2.11	1.64	1.44	0.47	0.67
17	0.84	2.30	1.82	1.43	0.48	0.87
18	0 90	2.51	2.06	1.47	0.45	1.04
19	0.94	2.72	2.28	1.52	0.44	1.20
20	0.98	+2.92	2.47	+1.56	0.46	—1.36
21	—0.84	—0.74	—1.23	—0.01	0.49	+0.73
22	0.89	0.56	1.09	0.03	0.53	0.53
23	0.89	0.40	0.94	0.08	0.54	0.32
24	0.88	—1.19	—0.72	—0.08	—0.53	+0.11
25	0.88	0.00	0.50	0.10	0.50	—0.10
26	0.94	+0.14	0.33	0.14	0.47	0.28
27	0.96	0.31	—0.16	0.14	0.47	0.45
28	1.00	0.50	+0.05	0.13	0.45	0.63
29	1.10	0.58	0.19	0.29	0.39	0.87
30	1.21	0.70	0.34	0.38	0.36	1.08
31	1.32	0.88	0.54	0.40	0.34	1.28
32	1.41	0.96	0.62	0.65	0.34	1.61
33	1.54	1.05	0.74	0.82	0.31	1.87
34	—1.68	+1.14	+0.86	—1.03	—0.32	—2.17
35	1.81	1.26	0.99	1.21	0.27	2.47
36	1.89	1.40	1.18	1.40	0.22	2.80
37	1.99	1.54	1.34	1.55	0.20	3.09
38	2.04	1.64	1.48	1.81	0.16	3.45
39	—2.08	1.81	1.66	2.02	0.15	3.83
40	+7.90	+2.02	+1.91	+2.12	—0.11	—4.14

—0″.75 = —4″.03 1st Meas. − 3″.80 2d Meas. = Set back

—0″.88 = Set back = —3″.80 2d Meas., +2″.92 − 10″.00 = Set back in 1st Meas.

+1″.33 = Set back = —3″.80 2d M. +0.″78 + 1″.99 = Set for'd in 4th Meas.

+0″.06 = Set back = —3″.80 2d Meas. —2″.30 5th Meas.

Set forward = +1″.99 4th Meas. − 0″.58 = +1″.41 4th Meas. − 2″.12 − 1″.20 Cor. of +1″.20 in 5th Meas.

+0″.05 = Set back = —2″.30

End of first measurement ahead, or east of △ E. base = 0.″20 = 0″.01667
End of second measurement ahead, or east of △ E. base = 8.″11 = 0′. 67583
End of third measurement ahead, or east of △ E. base = 6.″10 = 0′. 50833
End of fourth measurement ahead, or east of △ E. base = 6.″20 = 0′. 51667
End of fifth measurement ahead, or east of △ E. base = 10.″23 = 0′. 85250

* This result was rejected in the field (see notes). It would also be rejected by Pierce's criterion. (See Lee's tables, page 289.)

Running-water base (south part). Temperatures during measurements.

No. of tape.	First measurement.			Second measurement.			Third measurement.			Fourth measurement.			Fifth measurement.		
	Oct. 5, 1889. P. M.	Thermometers.		Oct. 8, 1889. A. M.	Thermometers.		Oct. 8, 1889. P. M.	Thermometers.		Oct. 9, 1889. P. M.	Thermometers.		Oct. 9, 1889. P. M.	Thermometers.	
		5100	5107		5100	5107		5100	5107		5100	5107		5100	5107*
	H. M.	°	°	*H. M.*	°	°	*H. M.*	°	°	*H. M.*	°	°	*H. M.*	°	
1	6 45	36.8	39.5	8 17	50.5	49.8	3 59	79.5	79.5	6 20	60.5	60.0	10 15	53.2	.....
2	.....	35.0	36.7	.....	51.5	52.2	.....	78.6	79.4	6 30	58.7	58.5	.....	52.6	.....
3	6 55	34.8	36.2	8 21	53.2	52.0	4 04	79.0	78.5	.....	60.2	58.5	10 20	50.2	.....
4	.....	35.8	36.0	.....	52.6	53.1	.....	79.5	79.4	.....	61.4	61.4	.....	53.0	.....
5	7 05	36.5	35.4	.....	53.2	53.0	.....	79.0	79.5	.....	61.0	61.5	.....	56.0	.....
6	.....	35.5	36.5	8-27	53.0	53.0	4 11	79.5	79.5	6 38	61.5	62.2	.....	53.2	.....
7	.....	36.1	36.5	.....	53.0	53.0	.....	79.4	78.8	.....	61.5	61.0	10 29	55.0	.....
8	7 28	36.0	36.6	.....	52.8	53.2	.....	78.5	79.0	.....	61.2	60.5	.....	52.6	.....
9	.....	35.0	36.8	8 36	53.6	54.0	.....	78.2	78.8	6 50	59.4	60.4	10 38	55.6	.....
10	7 39	34.1	34.4	.....	53.5	54.8	.....	78.2	77.6	.....	61.0	60.5	.....	47.0	.....
11	.....	35.5	34.9	.....	53.0	55.2	4 21	78.0	78.2	.....	60.6	60.0	.....	45.0	.....
12	7 46	34.1	35.2	.....	53.2	54.9	.....	77.4	78.2	.....	61.0	60.9	..	46.2	.....
13	.....	32.7	32.5	8 44	53.6	55.0	.....	77.2	78.0	6 59	61.2	60.5	10 47	47.5	.....
14	.....	33.4	32.6	.....	53.8	54.6	4 27	77.0	77.5	.....	61.0	61.2	.....	48.4	.....
15	.....	33.0	33.0	.....	54.8	54.8	.....	76.8	77.8	.....	60.8	60.4	.....	49.0	.....
16	.....	33.1	33.2	.....	55.6	56.0	.....	77.2	77.5	.....	60.5	60.5	.....	47.0	.....
17	7 58	33.6	32.0	8 52	55.4	56.2	.....	77.5	77.6	7 10	60.6	60.5	10 55	45.2	.....
18	.....	32.8	32.5	.....	55.8	56.0	4 34	77.2	77.2	.....	59.4	59 6	.....	42.8	.....
19	8 09	32.8	33.0	.....	55.2	55.8	.....	76.5	76.5	.....	58.8	59.5	.....	42.6	.....
20	.....	33.0	33.5	8 57	56.2	56.1	.....	76.0	76.4	.....	59.5	58.0	.....	43.6	.....
21	8 14	32.5	32.5	.....	56.2	56.7	4 40	76.0	75.9	7 21	60.5	58.7	11 05	41.8	.....
22	.....	33.5	31.7	9 01	56.0	56.6	4 42	76.0	76.2	.....	60.6	59.5	.....	43.5	.....
23	8 18	32.6	33.0	.....	56.0	56.5	.....	76.6	76.5	.....	61.0	60.5	.....	44.4	.....
24	.....	31.8	33.0	.....	56.5	56.8	.....	76.0	76.5	.....	61.5	60.7	11 11	43.2	.....
25	8 24	32.4	32.2	9 12	58.0	57.2	.....	76.4	76.4	7 32	62.2	61.5	11 17	41.2	.....
26	.....	30.0	32.0	.....	58.0	58.0	4 49	76.0	76.0	.....	61.0	60.6	.....	42.5	.....
27	8 34	25.5	29.2	.....	58.4	58.0	.....	75.6	75.5	.....	61.4	60.8	.....	41.0	.....
28	.....	27.5	28.5	9 19	57.8	58.5	.....	75.6	75.5	.....	61.2	61.5	.....	40.0	.....
29	.....	27.7	28.7	9 23	58.6	58.4	.....	75.6	75.6	.....	61.0	61.2	.....	41.0	.....
30	8 49	27.8	28.0	9 28	59.4	59.2	4 57	75.0	74.8	7 43	60.4	60.2	11 34	41.2	.....
31	.....	28.2	28.5	.....	60.0	60.5	.....	74.0	74.6	.....	59.5	59.8	.....	42.0	.....
32	.....	31.5	28.6	.....	60.0	60.0	.....	74.0	73.8	.....	60.6	60.0	.....	42.5	.....
33	.....	31.0	32.0	9 34	60.4	60.2	.....	73.5	73.5	.....	62.0	60.4	.....	49.0	.....
34	8.59	31.2	31.8	.....	59.0	59.5	.....	73.6	73.5	.....	61.6	60.8	.....	45.6	.....
35	.....	30.8	32.0	.....	60.4	60.3	5 08	72.4	73.0	7 52	61.0	61.8	11 45	46.5	.....
36	.....	30.2	31.4	.....	60.2	60.8	.....	72.6	72.0	.....	61.0	61.0	.....	50.2	.....
37	9 07	32.6	30.5	9 41	61.2	61.0	5 11	72.5	72.5	8 01	60.8	57.5	11 50	45.8	.....
Means for each thermometer..		32.61	32.99	.....	55.94	56.24	.....	76.55	76.67	.....	60.73	60.33	.....	46.68	.....
Means for each measurement ..		32°.80		.....	56°.09		.....	76°.60		.....	60°.53		.....	46°.68	
Corrections.		+0.30		.....	+0.05		.....	0.00		.....	+0.05		.....	+0.17	
Corrected means....		33°.10		.....	56°.14		.....	76°.60		.....	60°.58		.....	46°.85	

* Broken.

Running-water base (north part). Temperatures during measurement.

No. of tape.	First measurement.			Second measurement.			Third measurement.		
	Oct. 8, 1889. P. M.	Thermometers.		Oct. 8, 1889. P. M.	Thermometers.		Oct. 8, 1889. P. M.	Thermometers.	
		5100	5107		5100	5107		5100	5107
	H. M.	°	°	*H. M.*	°	°	*H. M.*	°	°
38	1 17	80.5	77.5	1 50	81.6	80.0	2 23	80.0	79.5
39	.....	78.2	77.0	.....	78.6	79.2	2 26	79.8	80.0
40	1 22	77.6	77.2	1 55	78.5	78.6	.....	79.0	79.0
41	.....	77.0	79.0	.....	78.6	78.8	.....	79.5	78.8
42	1 27	79.0	79.0	1 59	80.0	79.0	2 35	79.5	80.0
43	.....	79.0	78.4	.....	78.2	78.6	.....	79.2	79.5
44	.....	78.0	78.5	2 03	80.0	79.4	2 40	79.2	79.8
45	1 33	78.2	78.0	.....	79.2	79.0	.....	79.0	79.6
46	.....	78.4	78.5	2 08	79.5	79.2	2 46	79.5	79.4
47	1 37	78.2	78.6	2 10	79.0	79.4	2 48	80.8	80.4
Means for each thermometer	.....	78.41	78.17	.....	79.32	79.12	.....	79.55	79.60
Means for each measurement	.....	78°.29		.....	79°.22		.....	79°.575	
Corrections	.....	0 .00		.....	0 .00		.....	0 .00	
Corrected means	.....	78°.29		.....	79°.22		.....	79°.575	

No. of tape.	Fourth measurement.			Fifth measurement.			Sixth measurement.		
	Oct. 8, 1889. P. M.	Thermometers.		Oct. 9, 1889. P. M.	Thermometers.		Oct. 9, 1889. P. M.	Thermometers.	
		5100	5107		5100	5107		5100	5107
	H. M.	°	°	*H. M.*	°	°	*H. M.*	°	°
38	5 15	71.2	72.0	8 08	52.2	52.2	8 45	55.0	56.2
39	.....	71.0	71.0	.....	54.5	53.2	.....	56.4	56.1
40	.....	70.0	70.8	.....	53.6	53.8	.....	56.2	55.4
41	.....	70.0	70.0	.....	53.2	53.8	.....	54.2	54.5
42	5 24	69.7	69.0	.....	53.0	54.0	8.56	53.2	52.6
43	.....	69.4	69.0	.....	54.6	53.5	.....	52.5	52.8
44	5 28	69.0	69.0	8 22	54.2	53.4	.....	52.6	52.6
45	.....	68.9	68.8	.....	55.4	53.3	9 03	51.6	52.3
46	.....	68.0	68.0	.....	55.2	53.8	.....	52.0	51.6
47	5.34½	68.0	67.3	8 30	54.6	53.3	9 08	51.5	51.7
Means for each thermometer	.....	69.52	69.49	.....	54.05	53.43	.....	53.52	53.58
Means for each instrument	.....	69°.505		.....	53°.74		.....	53°.55	
Corrections	.....	0 .00		.....	+0 .05		.....	+ 0 .05	
Corrected means	.....	69°, 505		.....	53°.79		.....	53°.60	

Running-water base (south part). Correction for inclination (i) of tape.

[Sin $i = \frac{h}{l}$. Correction $= l \times$ ver sin $i = l \times 2 \sin^2 \frac{1}{2} i$. l 300′ .02398 = length of tape No. III at 62° Fahr.]

No. of stake.	Elevation.	Difference of elevation = h.	Log. h.	Log. sin i = log. h − log. l.	i.*	Log. sin $\frac{1}{2} i$.	Log. sin^2 $\frac{1}{2} i$.	Log. l + log. ver sin i = log. $2l$ + log. sin $2\frac{1}{2} i$.	Correction.
	′	′			° ′ ″				
Base ..	6.332	.....	.....	.....	.....	.....	.....	.....	.....
1	4.070	2.262	0.35449	7.87733	0 25 56	7.57655	5.15310	7.93129	0.00854
2	3.633	0.437	9.64048	7.16332	5 00	6.86167	3.72334	6.50153	0.00032
3	3.081	0.552	9.74194	7.26478	6 20	6.96433	3.92866	6.70685	0.00051
4	3.081	0.000	.....	.....	.....	.....	.....	.....	.....
5	2.974	0.107	9.02938	6.55222	1 14	6.25378	2.50756	5.28575	0.00002
6	1.874	1.100	0.04139	7.56423	12 36	7.26307	4.52614	7.30433	0.00202
7	2.244	0.370	9.56820	7.09104	4 14	6.78938	3.57876	6.35695	0.00023
8	2.147	0.097	8.98677	6.50961	1 06	6.20409	2.40818	5.18637	0.00002
9	1.431	0.716	9.85491	7.37775	8 12	7.07651	4.15302	6.93121	0.00085
10	1.909	0.478	9.67943	7.20227	5 28	6.90042	3.80084	6 57903	0.00038
11	1.401	0.508	9.70586	7.22870	5 50	6.92861	3.85722	6.63541	0.00043
12	0.875	0.526	9.72099	7.24383	6 02	6.94325	3.88650	6.66469	0.00046
13	1.618	0.743	9.87099	7.39383	8 30	7.09211	4.16422	6.96241	0.00092
14	1.621	0.003	7.47712	4.99996	0 02	4.68557	9.37114	2.14933	0.00000
15	0.828	0.793	9.89927	7.42211	9 06	7.12174	4.24348	7.02167	0.00105
16	1.926	1,098	0.04060	7.56344	12 34	7.26192	4.52384	7.30203	0.00200
17	2.174	0.248	9.39445	6.91729	2 50	6.61499	3.22998	6.00817	0.00010
18	0.897	1.277	0.10619	7.62903	14 38	7.32804	4.65608	7.43427	0.00272
19	1.642	0.745	9.87216	7.39500	8 32	7,09381	4.18762	6.96581	0.00092
20	1.065	0.577	9.76118	7.28402	6 36	6.98224	3.96448	6.74267	0.00065
21	1.131	0.066	8.81954	6.34238	0 46	6.04730	2.09460	4.87279	0.00001
22	1.037	0.094	8.97313	6.49597	1 04	6.19072	2.38144	5.15963	0.00001
23	0.988	0.049	8.69020	6.21304	0 34	5.91602	1.83204	4.61023	0.00000
24	0.860	0.128	9.10721	6.63005	1 28	6.32903	2.65806	5.43625	0.00003
25	0.900	0.040	8.60206	6.12490	0 28	5.83170	1.66340	4.44159	0.00000
26	1.346	0.446	9.64933	7.17217	5 06	6.87027	3.74054	6.51873	0.00063
27	1.062	0.284	9.45332	6.97616	3 16	6.67680	3.35360	6.13179	0.00014
28	0.231	0.831	9.91960	7.44244	9 32	7.14194	4.28388	7.06207	0.00115
29†	0.000	0.231	9.36361	6.88645	2 38	6.58320	3.16640	5.94459	0.00009
30	1.438	1.438	0.15776	7.68060	16 28	7.37930	4.75860	7.53679	0.00344
31	1.989	0.551	9.74115	7.26399	6 18	6.96204	3.92408	6.70227	0.00060
32	4.231	2.242	0.35064	7.87348	25 42	7.57263	5.14526	7.92345	0.00838
33	1.759	2.472	0.39305	7.91589	28 20	7.61499	5.22498	8.00817	0.01019
34	2.867	1.108	0.04454	7.56738	12 42	7.26650	4.53300	7.31119	0.00205
35	2.894	0.027	8.43136	5.95420	0 18	5.63982	1.27964	4.05783	0.00000
36	0.958	1.936	0.28691	7.80975	22 12	7.50905	5.01310	7.79629	0.00666
37	3.486	2.528	0.40278	7.92562	28 58	7.62459	5.24918	8.02737	0.01065
Sum =	74.000				Correction for inclination of tape (south part) = ...				0.06557

*On account of using half this angle the nearest even second is taken.
†Stake 29, being the lowest point, is taken as zero.

Running-water base (north part), correction for inclination (i) of tape.

[Sin $i = \frac{h}{l}$. Correction $= l \times$ versin $i = l \times 2 \sin^2 \frac{1}{2} i$. l = 300.02398 = length of Tape No. III at 62° Fahr.]

No. of Stake.	Elevation.	Difference of elevation = h.	Log. h.	Log. sin i = log. h − log. l.	i.*	Log. sin $\frac{1}{2} i$.	Log. sin^2 $\frac{1}{2} i$.	Log. l + log. ver sin i = log. $2l$ + log. sin^2 $\frac{1}{2} i$.	Correction
	′				° ′ ″				′
38	2.239	1.247	0.09587	7.61871	0 14 18	7.31803	4.63606	7.41425	0.00260
39	0.691	1.548	0.18977	7.71261	17 44	7.41149	4.82298	7.60117	0.00359
40	0.161	0.530	9.72428	7.24712	6 04	6.94565	3.89130	6.66949	0.00047
41	0.143	0.018	8.25527	5.77811	0 12	5.46373	0.92746	3.70565	0.00000
42	0.476	0.333	9.52244	7.04528	3 48	6.74248	3.48496	6.26315	0.00018
43	1.136	0.660	9.81954	7.34238	7 34	7.04160	4.08320	6.86139	0.00073
44	0.376	0.760	9.88081	7.40365	8 42	7.10222	4.20444	6.98263	0.00095
45	1.760	1.384	0.14114	7.66398	15 52	7.36318	4.72636	7.50455	0.00320
46	1.706	0.054	8.73239	6.25523	0 38	5.96433	1.92866	4.70685	0.00001
47	2.550	0.844	9.92634	7.44918	9 40	7.14797	4.29594	7.07413	0.00119
								Correction for inclination of tape (north part) =	0.01333
Sum =	11.238								
Sum =	74.000	brought forward.							
	85.238								
	48 = 1′.7758								

*On account of using half this angle the nearest even second is taken.

Hence 1.776 = mean elevation of total base above lowest point.

804.450 = elevation of zinc △ S. base above St. Louis City directrix.
412.71 = elevation of St. Louis City directrix above sea-level.
1217.160 = elevation of zinc △ S. base above sea-level.
4.556 = elevation of zinc △ S. base above mean elevation of base.
1212.604 = mean elevation of running-water base above sea-level.

Correction to reduce to sea-level:

$\delta = \frac{Ba}{N.}$ (See Lee's tables, p. 84.)

log B = log 14102′.34519 = 4.1492913
log a = log 1212.604 = 3.0837190

7.2330103
log N (at Lat. 42° 46′) = 7.3213056

log correction = 9.9117047
Hence correction = 0′.81603

Running-water base (south part).

Five measurements expressed by the following equations:

(First) [37×300′.02398]—2′.21683+2′.83417 +0′.23167—0′.06527=11101′.67100
(Second) [37×300′.02398]—0′.44950+0′.83250 +0′.49917—0′.06527=11101′.70416
(Third) [37×300′.02398]+1′.11992—0′.10000*+0′.16417—0′.06527=11102′.00608
(Fourth) [37×300′.02398]—0′.10892+0′.50000 +0′.68583—0′.06527=11101′.89890
(Fifth) [37×300′.02398]—1′.16211+1′.41583 +0′,74417—0′.06577=11101′.81988

Mean=11101′.82000

First term is number of tapes into length of tape at 62° Fahr.
Second term is temperature correction to 62° Fahr.
Third term is distance set forward or back on zincs.
Fourth term is distance between end of last tape and △ stake 37.
Fifth term is correction for inclination of tape.
The second member is the corrected independent result for each measurement.

Running-water base (north part).

Six measurements expressed by the following equations:

(First) [10 × 300′.02398] + 0′.33769 — 0.05417 — 0.01333 = 3000.50999
(Second) [10 × 300′.02398] + 0′.35697 — 0.07458 — 0.01333 = 3000.50886
(Third) [10 × 300′.02398] + 0′.36433 — 0.06833 — 0.01333 = 3000.52247
(Fourth) [10 × 300′.02398] + 0′.15558 + 0.17750 — 0.01333 = 3000.55955
(Fifth) [10 × 300′.02398] — 0′.17019 + 0.47000 — 0.01333 = 3000.52628
(Sixth) [10 × 300′.02398] — 0′.17413 + 0.47167 — 0.01333 = 3000.52401

Mean... = 3000.52519

First term is number of tapes into length of tape at 62° Fahr. and 16 pounds tension.
Second term is temperature correction to 62° Fahr.
Third term is distance between end of last tape and △ N. base.
Fourth term is correction for inclination of tape.
The second member is the corrected independent result for each measurement.

Mean of six measurements (north part) = 3000′.52519
Mean of five measurements (south part) = 11101′.82000
Total length of running water base = 14102′.34519
Reduction to sea-level = —0′.81603

Running-water base reduced to sea-level = 14101′.52916

*This quantity is correction for using the graduation at 299.9 feet instead of 300.0 feet. (See field notes.)

Running-water base (south part). Measured differences on zincs.

Tape.	Measurements.				
	2d–1st.	2d–3d.	2d–4th.	2d–5th.	3d–4th.
	"	"	"	"	"
1	+0.28	−0.64	−0.21	−0.04	+0.43
2	0.64	1.26	0.34	0.00	0.92
3	1.04	1.85	0.51	0.02	1.33
4	1.42	2.44	0.66	0.02	1.77
5	1.80	3.03	0.86	0.06	2.17
6	2.15	3.61	1.03	0.03	2.57
7	2.53	*†3.02	1.24	0.09	*†1.78
8	2.91	3.58	1.36	0.04	+2.20
9	−2.66	−0.12	−3.48	−2.86	−3.36
10	2.24	0.62	3.58	2.66	2.96
11	−1.80	−1.14	3.75	−2.47	−2.61
12	1.33	1.64	3.86	2.24	2.21
13	0.81	2.11	3.96	2.02	1.84
14	−0.30	2.61	4.10	1.90	1.49
15	+0.35	3.09	4.21	1.70	1.12
16	0.79	3.49	4.23	1.37	0.74
17	1.36	3.94	4.28	1.08	−0.33
18	1.93	4.36	4.30	0.76	+0.07
19	−9.54	4.80	4.31	0.42	0.48
20	9.00	5.17	4.28	−0.08	0.89
21	−8.36	−5.54	−4.29	+0.31	+1.26
22	7.75	5.91	4.30	0.69	1.62
23	7.16	6.29	4.31	1.06	1.99
24	6.54	6.65	4.34	+1.44	2.32
25	5.90	6.99	4.34	−8.14	2.65
26	5.24	7.35	4.33	7.74	3.02
27	4.46	7.66	4.31	7.28	3.35
28	3.70	7.99	4.32	6.80	3.67
29	3.00	8.30	−4.28	−6.33	4.02
30	−8.21	−2.56	+1.76	+0.16	4.31
31	−7.44	−2.80	+1.84	+0.65	+4.64
32	6.75	3.04	1.90	1.03	4.94
33	6.03	3.24	1.96	1.40	5.20
34	5.33	3.45	2.02	1.84	5.48
35	4.67	3.66	2.04	2.17	5.70
36	3.96	3.86	2.09	2.47	5.95
37	−3.22	−4.02	+2.24	+2.94	+6.26

Set ahead { 1st M. = +12″.00, 2d M. = + 5″.99. 1st M. } = +12″.01. Set ahead { +10″.00, 1st M. + 4″.00, 2d M. } = −3″.09

−10″.08

Set ahead = + 4″.00, 2d M. = +0″.42

Set ahead = +5″.99, 2d M. = −2″.31

Set ahead { +6″.00, 4th M. +4″.00, 2d M. } = −3″.36

Set ahead = +5″.99, 2d M. = +1″.71

Set ahead { +7″.00, 5th M. +4″.00, 2d M. } = −3″.04

Set ahead = +5″.99, 2d M. = −8″.55

Set ahead = +9″.99, 5th M. = −3″.80

Set ahead = +6″.00, 4th M. = −9″.01

* The graduation mark 299.9 feet used instead of 300-foot mark.
† +1″.20 for wrong work.

End of first measurement back, or south of △ stake 37 = 2″.78 = 0′.23167
End of second measurement back, or south of △ stake 37 = 5″.99 = 0′.49917
End of third measurement back, or south of △ stake 37 = 1″.97 = 0′.16417
End of fourth measurement back, or south of △ stake 37 = 8″.23 = 0′.68583
End of fifth measurement back, or south of △ stake 37 = 8″.93 = 0′.74417

Running-water base (north part). Measured differences on zincs.

Tape.	Measurements.				
	2d–1st.	2d–3d.	2d–4th.	2d–5th.	2d–6th.
	"	"	"	"	"
38	+0.02	+0.03	+0.29	+0.72	+0.[illegible]
39	0.13	0.07	0.58	1.38	1.[illegible]
40	0.12	0.06	0.82	1.98	1.[illegible]
41	0.16	0.09	1.10	2.62	2.[illegible]
42	0.21	0.09	1.43	3.33	3.[illegible]
43	0.24	0.12	1.73	3.98	3.[illegible]
44	0.26	0.14	2.05	4.65	4.[illegible]
45	0.24	0.13	2.34	5.26	5.[illegible]
46	0.26	0.12	2.70	5.90	5.[illegible]
47	+0.24	+0.07	+3.02	+6.54	+6.[illegible]

End of first measurement ahead, or north of △ N. base = 0″.65 = 0′.05417
End of second measurement ahead, or north of △ N. base = 0″.895 = 0′.07458
End of third measurement ahead, or north of △ N. base = 0″.82 = 0′.06833
End of fourth measurement back, or south of △ N. base = 2″.13 = 0′.17750
End of fifth measurement back, or south of △ N. base = 5″.64 = 0′.47000
End of sixth measurement back, or south of △ N. base = 5″.66 = 0′.47167

APPENDIX B.

ANNUAL REPORT OF FIRST LIEUTENANT HIRAM M. CHITTENDEN, CORPS OF ENGINEERS, 1889–'90.

UNITED STATES ENGINEER OFFICE,
Omaha, Nebr., June 30, 1890.

SIR: I have the honor to submit the following report of operations pertaining to the improvement of that portion of the Missouri River above Sioux City, Iowa, during the year ending June 30, 1890.

A statement of the previous history of the work, of the past and present projects of improvement, of the amount of work hitherto done and of the results obtained, is given in my last annual report. (Report Chief of Engineers, 1889, Part IV, page 2750.)

At the date of that report work had been in progress about six weeks, and as the work at no single place had yet been completed, I will include in this report a full statement of all that was done during the working season.

The obstructions to navigation which the work of the season was intended to remove, consisted in almost all cases of gravel bars. The improvement work was directed to securing a navigable channel over these bars. This was accomplished by a contraction of the water-way so as to force more water over the bar, and by the removal or cutting away of a portion of the latter. The contraction of the water-way was secured by means of dams, and the removal of the bars by means of a dredge. The dams were in all cases built of willow fascines loaded with rock after being put in place. (Fig. 1, accompanying drawings.) The willow grows in great abundance along the banks, and the rocks, though not plentiful, still exist in sufficient quantities for the needs of the work.

Improvement work was carried on at six different points, as follows:

BAKER'S BAR (FIG. 2).

At this point the river divides into two channels, the smaller carrying about one-third of the water of the river. The obstruction consisted of a bar at the mouth of the larger chute. The smaller chute was completely dammed off, and a narrow channel about 6 feet deep was dredged through the bar. The action of the current had considerably enlarged it before the close of the season's work.

SHONKIN BAR (FIG. 3).

The only work done here was to repair the old dams.

EVANS' BEND (FIG. 4).

The river at this point divides into two channels, the smaller carrying about one-fourth of the water of the river. The obstruction consisted of a shoal at the head of the larger chute, and a very sharp bend in the channel a short distance below. The smaller chute was completely cut off. A dam was built out from the right bank of the larger chute so as to straighten the channel. A cut of considerable length was made by the dredge through the shoal and opposite the end of the dam.

CROCONDUNEZ (FIG 5).

A wing-dam was built from the right bank, so as to contract the channel over the shoal, through which, and opposite the outer end of the dam, a deep channel was dredged.

FONTONELLE BAR (FIG. 6).

This point received more attention than any other during the season. The main channel follows along the left bank of the river, but two smaller chutes, carrying together at least one-third of the river, flowed along the right bank, separated from the main channel by an island of considerable size. At the mouth of the main chute the water flowed over a broad fan-shaped bar, very shallow, until it finally reached the smaller chutes at the right bank. Even in a good stage of water it was very difficult to carry a boat over this bar. To remove the obstacle both right-hand chutes were cut off, as well as a minor one on the left bank. A long wing-dam was built from the right bank, below the island, out to the center of the above-mentioned bar. A deep cut was dredged across the bar opposite the end of the dam, thus entirely straightening the channel.

SENIEUR'S REACH (FIG. 7).

The river at this point spread out to unusual width, and, although there was no bar, as in the above cases, the depth over the entire reach was very shallow. The channel was contracted about one-third by building three wing-dams from the left bank.

Below is a tabulated statement of the amount of material used in these dams, and the amount of dredging done:

	Fascines.	Rock.	Gravel, loose.	Gravel.	Gravel removed by dredge.
		Cu. yds.	*Cu. yds.*	*Sacks.*	
Baker's Bar	941	119	1,100	2,296	7,200
Shonkin Bar	77	.....	48	346	.....
Evans' Bend	982	135	1,165	.....	3,600
Crocondunez	473	137	800	272	4,100
Fontonelle	1,818	273	813	949	8,788
Senieur's Reach	1,356	225	325	.....	.....
Total	5,647	889	4,251	3,863	23,688

Two difficulties which work of the above description is likely to produce were guarded against as much as possible.

(1) The waste gravel from dredging was cast in such places, with reference to the current, that it would be washed where it was desirable to have a bar form, thus keeping it from lodging in the main channel.

(2) It is well known that the simple removal of bars which are obstacles to navigation will not produce the desired relief. The bar is itself a dam in the river. Upon its existence depends the depth of water in the pool above. If it is removed, it simply discharges the pool, and is certain to produce a new shoal above. It follows then that cutting away these shoals is of doubtful utility, unless some compensation is provided for the consequent drainage of the river above. In the work above described, it is believed that this difficulty has been evaded by forcing a much larger amount of water to flow over the bars where dredging has been done. By cutting off side-channels or building wing-dams, the current in the main channel has been, in each of the above cases, increased by about one-half its original size. This will probably more than make up for the lowering of the river produced by dredging the bars.

In addition to the construction work above described, a careful topographical survey was made of the river valley, from 3 miles above Benton to the Coal Banks, supplemented by a thorough hydrographic survey of the river. This work has been entirely mapped and submitted to the Commission.

The season was a remarkable one in the history of the river, from the very low stage of water reached; nearly 1 foot less than any previous record. An accurate measurement of the river at its lowest stage showed the discharge to be only 2,829 cubic feet per second. There was scarcely a mile of the river, for 80 miles below Benton, where shoals were not encountered of less depth than 1 foot. Should this prove to be the future normal condition of the river at low water, it will entirely change the problem of making it navigable. The present project was, of course, not designed to meet it.

The result of last season's work, in the matter of increased depth is shown in the accompanying plats of surveys of the portions improved, both before and after improvement. A portion of this work was completed but a short time before the final survey, and none of it had passed through the season of high water, so that the showing can not be considered complete. It was not practicable to inspect the work this season after the subsidence of high water and in time for this report. It may be stated, however, that the increased depth of the channel over which work was carried was sufficient for the passage of the Government steamer *Josephine* where it would have been impossible to have moved her a mile before. This was at the very low stage of water referred to above.

STATISTICS.

Application was made to various parties along the river for statistics as to both the actual amount of commerce carried on upon the river during the past year, and the commercial products of the river valley.

The following statement, furnished by I. P. Baker, general superintendent Benton Transportation Company, was the only reply received.



MISSOURI RIVER COMMISSION.

MISSOURI RIVER

OUTLINE MAP

SHOWING

SOUNDINGS TAKEN BEFORE IMPROVEMENT

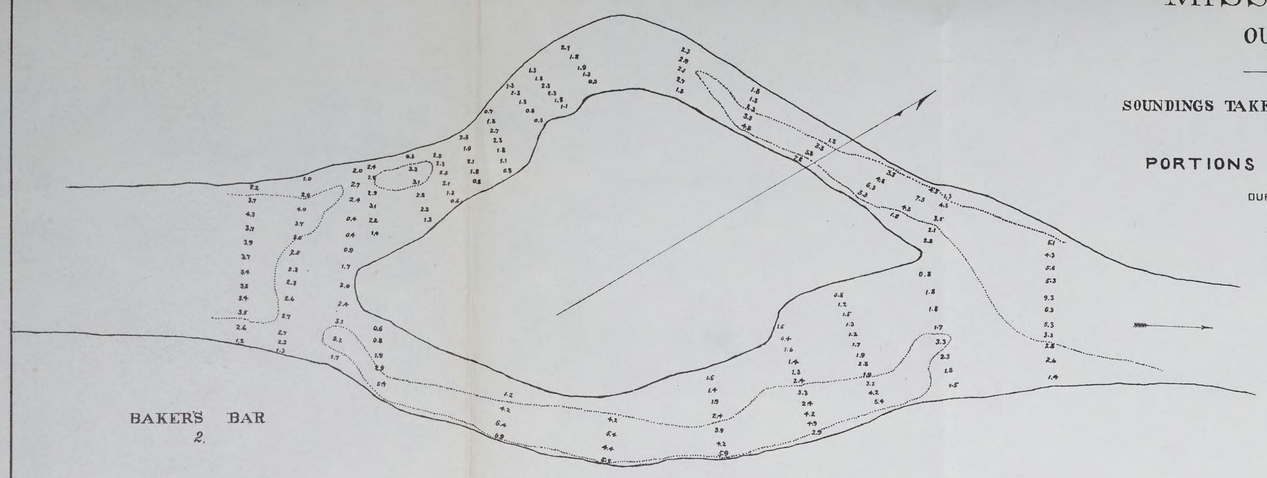
ON

PORTIONS OF RIVER IMPROVED

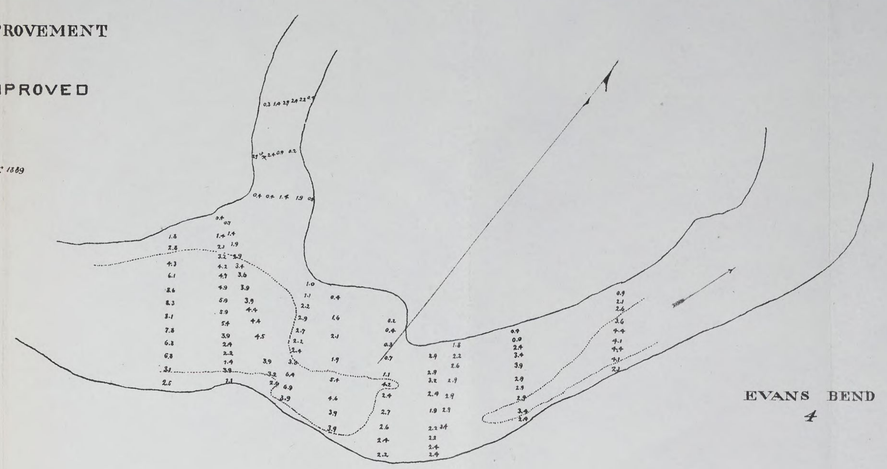
DURING SEASON OF 1889.

SCALE: ONE IN. = 300 FT.

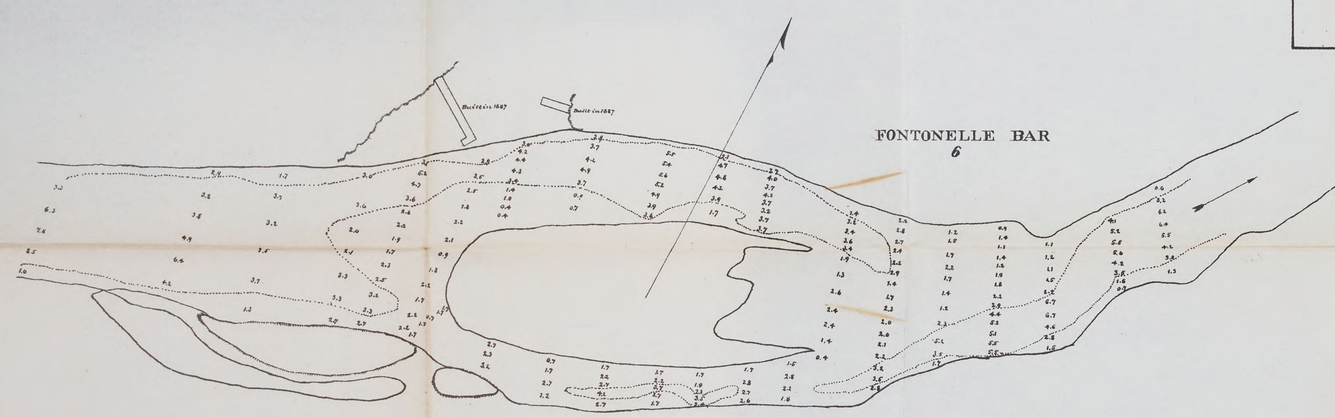
Soundings reduced to L. W. 1889



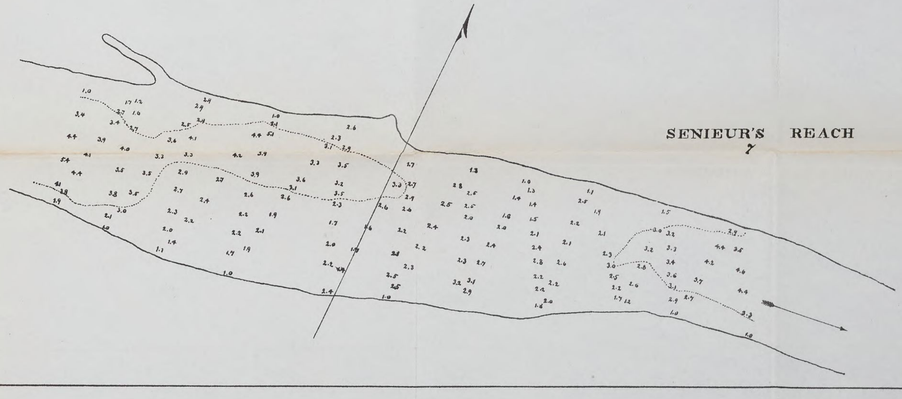
BAKER'S BAR
2.



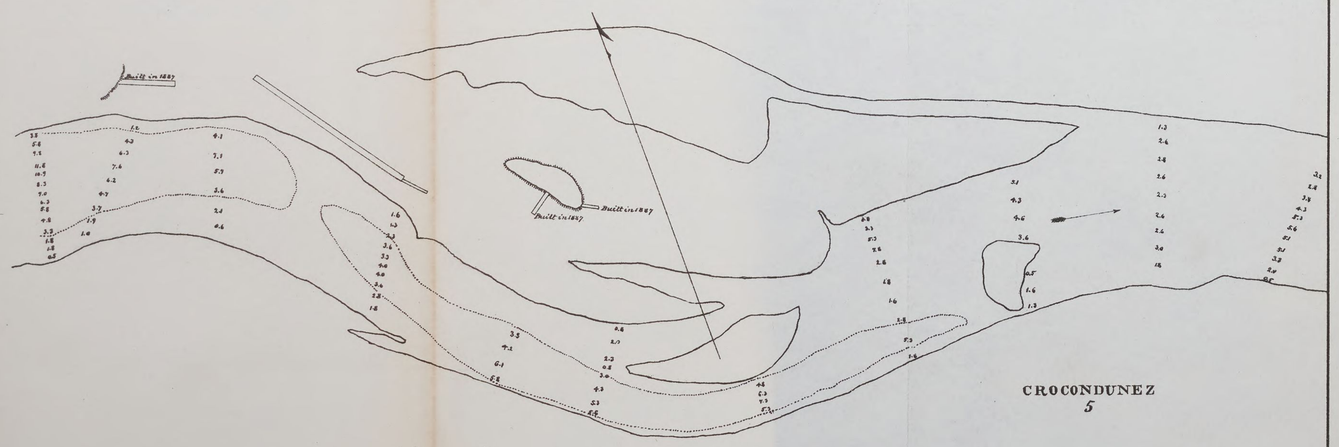
EVANS BEND
4



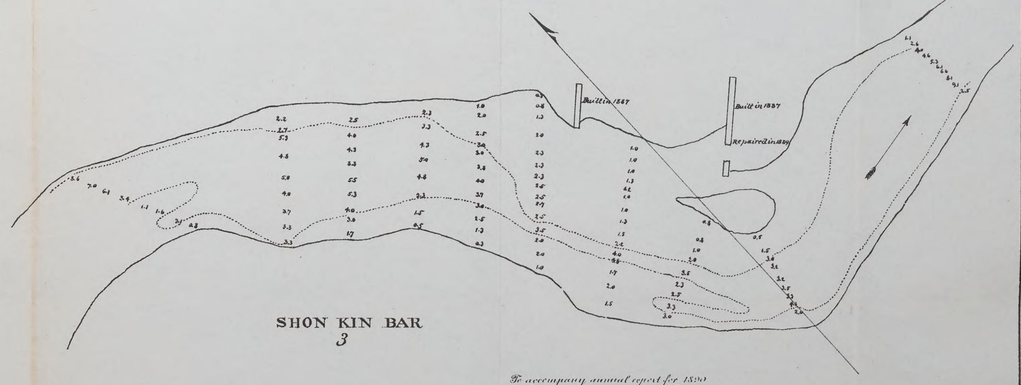
FONTONELLE BAR
6



SENIEUR'S REACH
7

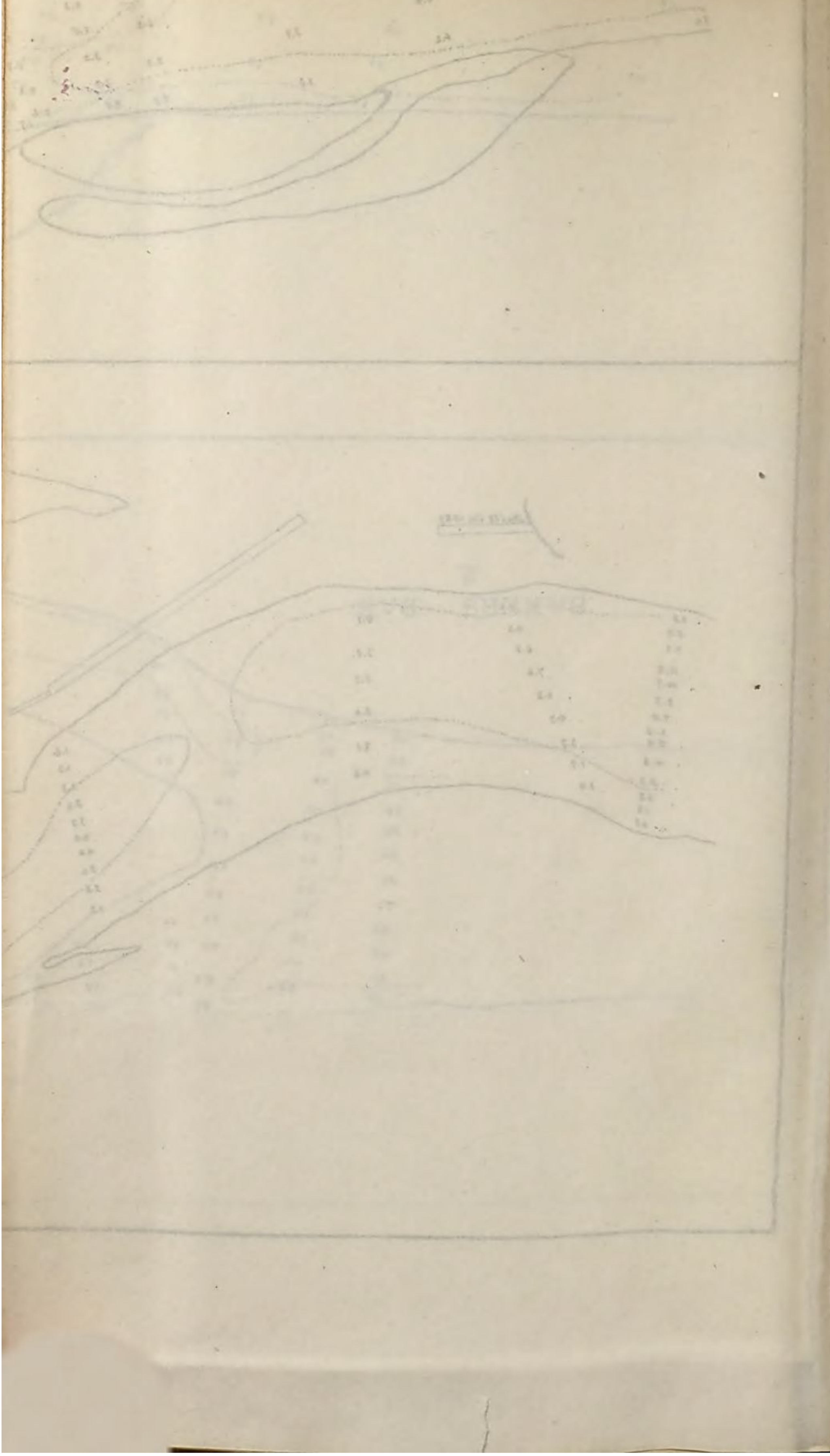


CROCONDUNEZ
5



SHON KIN BAR
3

To accompany annual report for 1890
of First Lieutenant Hiram M. Chittenden,
Corps of Engineers.



MISSOURI RIVER COMMISSION.

MISSOURI RIVER

MAP

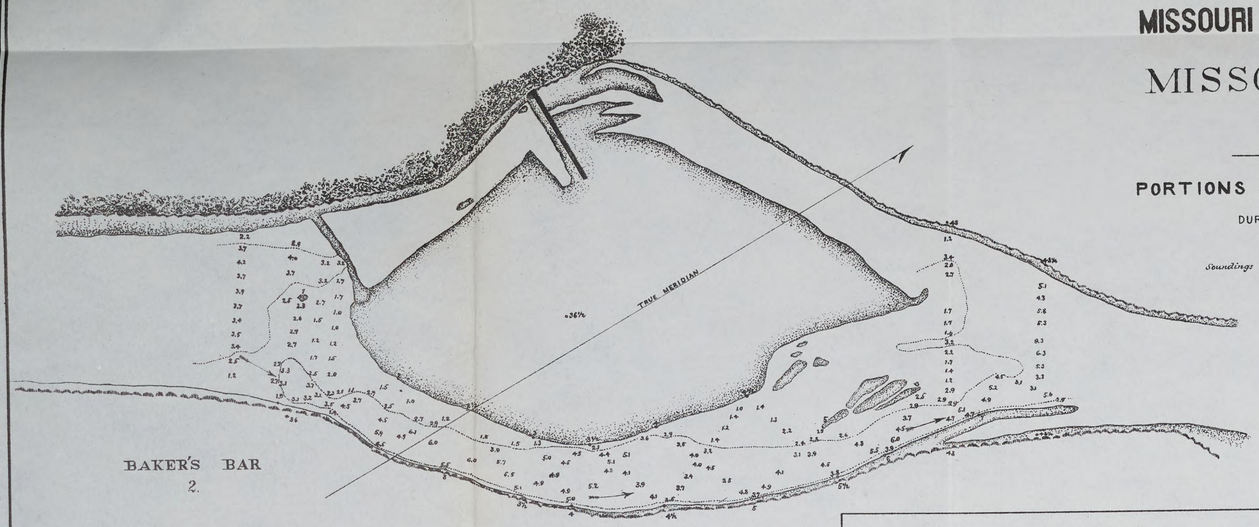
SHOWING

PORTIONS OF RIVER IMPROVED

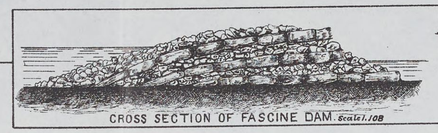
DURING SEASON OF 1889.

SCALE ONE IN = 300 FT.

Soundings reduced to low water 1889

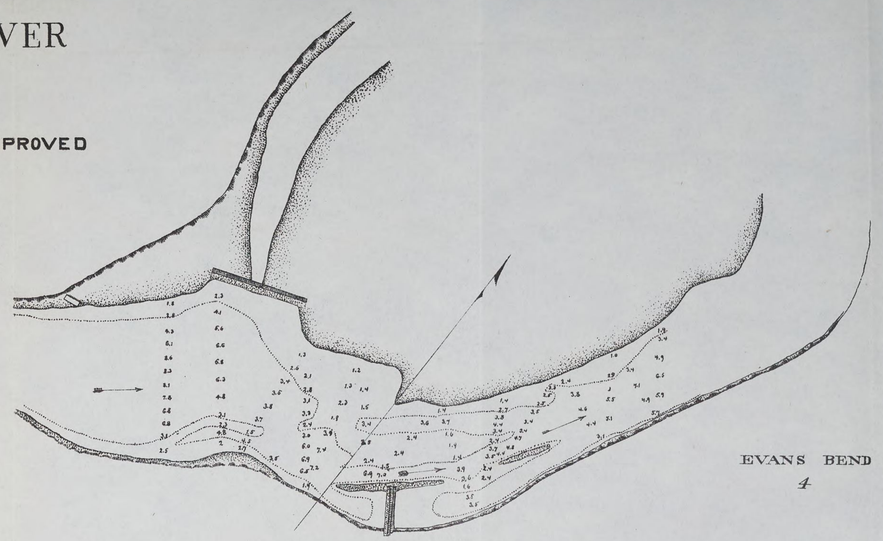


BAKER'S BAR
2.

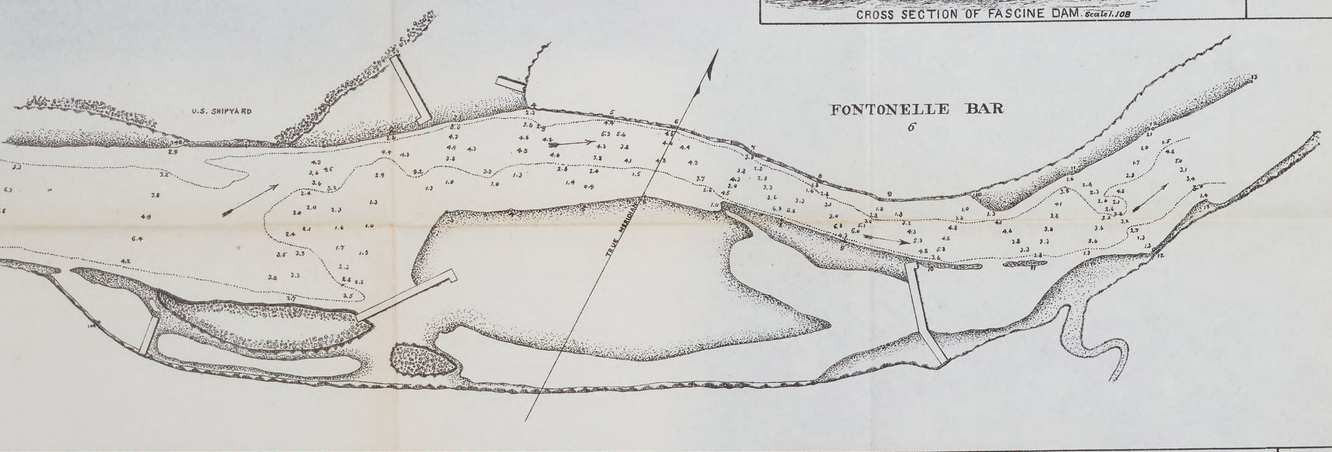


1

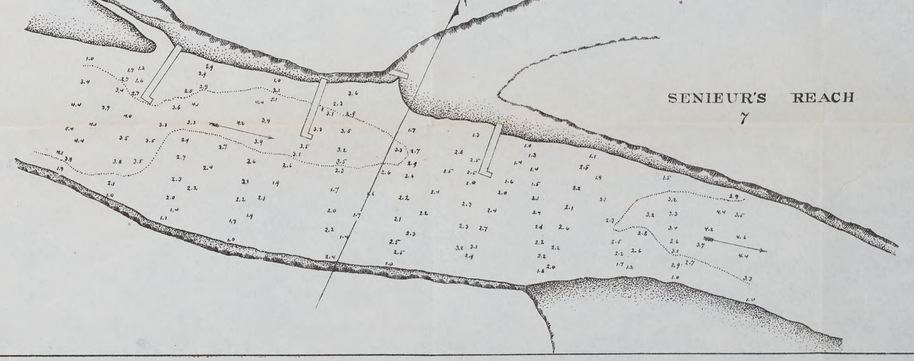
CROSS SECTION OF FASCINE DAM. *Scale 1:108*



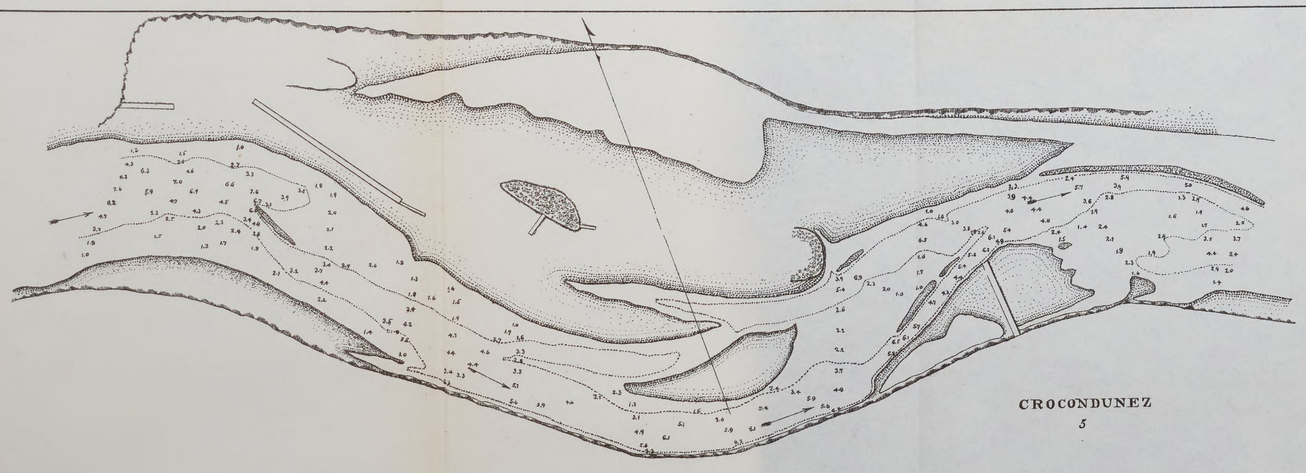
EVANS BEND
4



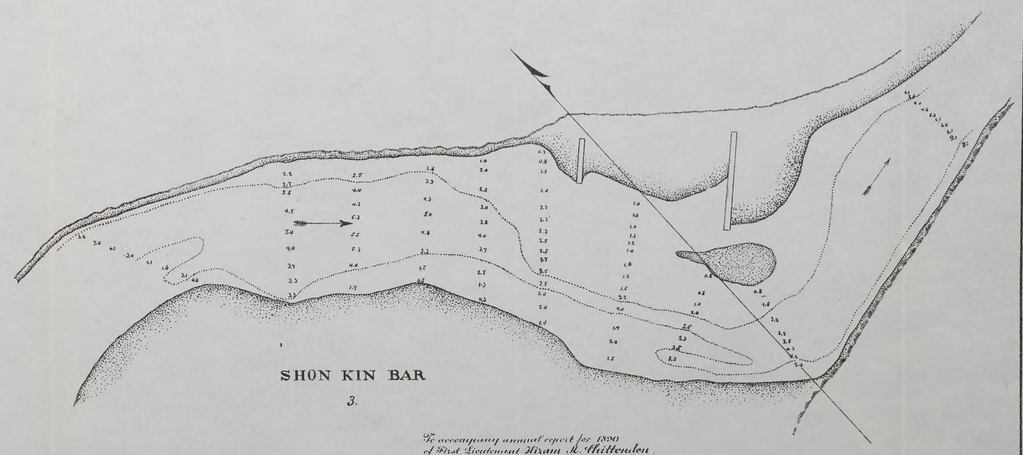
FONTONELLE BAR
6



SENIEUR'S REACH
7



CROCONDUNEZ
5



SHON KIN BAR
3.

To accompany annual report for 1890
of First Lieutenant Hiram M. Chittenden
Corps of Engineers.

Eng. 90

Statement of tonnage carried by steam-boats on the Upper Missouri River, to and from Sioux City, Iowa, Fort Benton, Montana, and intermediate points, for the season of 1889.

Between Sioux City and Bismarck:

	Pounds.
Merchandise, private	3,674,657
Merchandise, military	1,384,851
Merchandise, Indian	581,733
Hides and wool	656,375
Anthracite coal	6,943,980
Grain	9,913,867
Flour	1,986,731
Lumber	2,933,837
Bones	1,167,083
Total	29,243,114

(or 14,621 tons 1,114 pounds.)

Between Bismarck and Fort Benton:

	Pounds.
Merchandise, private	1,406,444
Merchandise, military	12,643
Merchandise, Indian	288,610
Hides and wool	268,134
Grain	1,124,100
Flour	366,900
Bones	736,975
Total	4,203,806

(or 2,101 tons 1,806 pounds.)

Gross tonnage transported, 16,723 tons, 920 pounds.

Number of trips made by boats.

Bismarck to Fort Benton	2
Bismarck to Berthold and way points	7
Bismarck to points below	59
Total	68

Grain raised tributary to the Missouri River and transported by steamers on that river, between Fort Yates and Fort Berthold.

	Pounds.	Bushels.
Corn	510,720	9,120
Oats	352,320	11,010
Wheat	2,477,280	41,288
Total	3,340,320	61,416

Money value of tonnage transported, in round numbers.

Below Bismarck:	
Merchandise, private 1,837 tons; merchandise, military, 692 tons; merchandise, Indian, 291 tons; total 2,820 tons	$318,400.00
Coal, anthracite, 3,472 tons	45,136.00
Oats, 500 tons, $10,000; wheat, 3,000 tons, $90,000; corn, 1,451 tons, $21,756; total, 4,951 tons	121,756.00
Flour, 993 tons	49,650.00
Lumber, 1,466 tons	29,320.00
Bones, 583 tons	3,498.00
Hides and wool	78,720.00
Above Bismarck:	
Bones, 368 tons	2,208.00
Flour, 183 tons	9,150.00
Grain (wheat), 562 tons	16,860.00
Hides, 134 tons	32,160.00
Merchandise, private, 703 tons; merchandise, military, 6 tons; merchandise, Indian, 144 tons; total, 853 tons	102,360.00
Total value	809,218.00

Money statement.

July 1, 1889, amount available		$27,088.48
Amount allotted by Missouri River Commission for surveys above Sioux City, Iowa, from appropriation act of August 11, 1888		4,000.00
Refunded, for over-payment		101.50
		31,189.98
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$24,354.51	
July 1, 1890, outstanding liabilities	1,451.96	
		25,806.47
July 1, 1890, balance available		5,383.51
Amount (estimated) required for completion of existing project		250,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		125,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

SUMMARY.

Officer in charge of work during year ending June 30, 1890, First Lieut. Hiram M. Chittenden, Corps of Engineers.

Improvement work hitherto confined to that portion of the river between Fort Benton and Carroll, Mont.

Original and present condition of channel below Carroll, sandy, shifting, and obstructed by snags.

No project exists for the improvement of this section except snagging, and no work under this project has ever been done.

Original condition of channel above Carroll gravelly and very stable, but obstructed by rapids, shoals, loose bowlders, and sharp turns.

Original and present project: Contraction of water-way so as to secure a navigable channel of 4½ feet depth at ordinary stages, by closing secondary channels, building wing-dams, dredging gravel shoals, and removing loose bowlders.

Amount expended on present project to close of fiscal year ending June 30, 1889, $278,689.37.

Condition June 30, 1889: Boats loaded to 3½ feet draught could make their way to Benton, except at lowest stages.

Amount expended during year ending June 30, 1890, $29,564.53.

The work secured a navigable channel over all places improved.

Stage of water during season, lowest ever known.

Impracticable to inspect works this season after high water and in time for annual report.

Respectfully submitted.

HIRAM M. CHITTENDEN,
First Lieutenant of Engineers.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

APPENDIX C.

ANNUAL REPORT OF MR. CHARLES F. POTTER, DIVISION ENGINEER.

OMAHA, NEBR., *June* 24, 1890.

COLONEL: I have the honor to submit the following report of operations under my charge, on the Missouri River in the vicinity of Omaha, Nebr., during the fiscal year ending June 30, 1890.

This report is accompanied by maps, sketches, and photographs, showing progress and nature of work done.

The work of improvement consisted in the construction of a continuous revetment, commencing at the Chicago and Northwestern Railway dykes on the left bank, and extending down stream a distance of 12,752 feet, in accordance with project submitted July 13, 1889, and approved July 25, 1889.

In addition to the above, a detached piece of revetment, 352 feet in length, was constructed, as a protection to the ways and boat-yards, making the total amount of revetment constructed during the year, 13,004 linear feet.

The general plan of revetment adopted is described as follows: A row of piling, 10 feet apart, was first sunk at the water's edge; a woven willow mattress was then constructed into the stream from the piling, and sunk to the bottom with rock. The bank was next graded to a uniform slope with the hydraulic grader. The piling was then anchored, by means of cables, to deadmen; and finally the exposed bank was covered with rock.

The revetment shown on the map between *a* and *b*, and the detached portion at the boat-yard, was constructed during August, September, October, and November, 1889, and between *b* and *c*, during April, May, and June, 1890.

SINKING PILES.

The piles were sunk by means of a jet, and were placed 10 feet apart at the water's edge. The stage of the river was practically at standard low-water mark when the piles were being sunk. The piles were live-oak, 20 feet in length, and not less than 10 inches in diameter at the smaller end.

The depth of penetration was 17 feet, thus allowing 3 feet to stand above the water at the time of sinking, and until the mattress could be constructed, in anticipation of a sudden rise in the river. Upon the completion of the other part of the revetment, the piles were cut off flush with the top of the rock.

The maximum number of piles sunk during any one day of ten hours during the year was 48.

The piles were furnished by the Howell Lumber Company, free on board cars, Omaha, for 14¼ cents per linear foot.

MATTRESS.

Willow brush was woven together, making a mattress 12 inches in thickness, commencing 1 foot inside of the piling and extending out into the stream a distance of 60 feet.

When the river stood above standard low-water mark, the mattress was extended inside the piling until solid ground was reached, which often resulted in making a total width of mattress of from 65 to 70 feet.

A longitudinal ¾-inch cable was woven into the outside selvage edge of the mattress. Six longitudinal ⅝-inch cables, 10 feet apart, extended through the mattress, one of them being placed just inside the piling. Transverse ⅝-inch cables, running through the mattress, connected each pile with the selvage ¾-inch cable.

The brush used for revetment *a* to *b* was furnished by W. H. B. Stout, and delivered on barges for $1.18 per cord.

Much delay in the work was caused by failure to furnish this material in the required quantities, and, in consequence, the brush used in the revetment from *b* to *c* was purchased standing, and cut and loaded on barges by hired labor.

Owing to the fact that the American Water Works Company have used about 20,000 cords of brush at Florence during the past year, the material has become very scarce in the immediate vicinity of Omaha. The last brush cut by us came from near Bellevue, Nebr.

GRADING BANK.

The bank was graded by the hydraulic method to a slope of three on one. From *a* to *b*, the bank consisted of a gumbo of the hardest type, held together with willow and cottonwood roots and stumps, which made the progress slow and expensive. From *b* to *c* the bank was of a sandy nature, and rapid progress was made.

Hydraulic grader No. 5 was abandoned on October 7, 1889, owing to the giving out of the left water cylinder. The cylinder had been patched previous to use here, and had given more or less trouble during the season. Pile-sinkers Nos. 3 and 14 were used to complete the grading.

ROCKING MATTRESS AND UPPER BANK.

The mattress was usually sunk with rock as soon as it was constructed; one-third of a cubic yard of rock per linear foot being used for this purpose.

The upper bank, as sloped, was rocked to the depth of one foot, extending from the piling to standard high-water line.

As previously mentioned, the line of piling was practically the standard low-water

line. For this part of the work about 1.1 cubic yards of rock per linear foot of bank was used.

The rock was furnished by Van Court & Lemist, delivered on barges at Omaha, Nebr., for $1.09 per cubic yard.

The material was limestone, quarried at Weeping Water, Nebr.

ANCHORAGE.

Three-eighths inch cable was made fast to each pile and carried back to a dead-man on top of the bank.

As above stated, cables connected the piles with the outer edge of the mattress; consequently, the system of anchorage was continuous throughout the whole structure.

TOWING.

All of the towing was done by the steamer *Capitola Butt*, which was chartered from Capt. O. Butt, on July 22, 1889, the compensation being $20 per day. She was in commission between the following dates, during the fiscal year: from July 22 to November 25, 1889, and from April 19 to June 21, 1890.

During July and August, 1889, three trips were made with her to Nebraska City for plant belonging to the Omaha Division, which the steamer *Alert* had left there, owing to the low water. A trip was also made to the same place in June, 1890, for the purpose of delivering to the St. Joseph Division hydraulic grader No. 5.

BOAT-YARD WAYS, ETC.

August 1, 1889, a tract of land was leased from John W. Paul for use as a boat-yard. The tract contains six acres, with a river frontage of 400 feet, and is located on the left bank of the Missouri River, about 3 miles above the Union Pacific Railroad Bridge. The lease was made for two years with the privilege of five years, and the compensation to be $50 per annum.

A warehouse, 24 by 60 feet, was built at the upper end of the yard for the purpose of storing tools and general supplies.

An ice-house, 12 by 24 feet, was constructed at the lower end of the yard and was filled with ice cut from the river during the winter.

Ways were constructed in October, 1889, of sufficient proportions to hold all the plant belonging to the Omaha Division. The ways were made in two sections as shown on accompanying sketch, the first one extending back from the inclined portion and needles, the second section being down-stream from and parallel to the first.

A carriage was constructed directly back of the trip-beams or needles, shown in the sketch, for transferring boats from one section to the other.

The inclined portion of the ways which extend into the river has a slope of 5 on 1.

Oak piling was driven 6 feet apart on the slope for the supports, and was capped with 10-inch by 10-inch timbers. The needles were made of 10-inch by 14-inch 26-foot timbers. In the main ways, 8-inch by 8-inch by 18-foot timbers were used, supported by posts 8-inch by 8-inch by 6-foot, placed 9 feet apart, being sunk into the ground 3 feet, and resting on 3-inch by 12-inch by 3-foot plank.

On top of all portions of the ways a 2-inch by 6-inch oak cap was spiked to lessen the friction and thereby facilitate the movements of the boats when being moved.

The entire fleet was pulled out on the ways during the month of November, 1889.

REPAIRS TO PLANT.

Work of repairing, calking, and launching boats was commenced the latter part of March, 1890, and was completed the first week in May. Only the repairs that were found absolutely necessary to render the boats serviceable were made.

TELEPHONE LINE.

A telephone line was built in September, 1889, from the warehouse to the east end of the Union Pacific Railway Bridge, a distance of 3¼ miles. Arrangements were then made with the Nebraska Telephone Company to furnish and maintain a wire connecting the Government line with the division engineer's office at Omaha, and to furnish two instruments for the line, compensation for all of which was $119.60 per annum.

CONSTRUCTION MATERIAL USED AT OMAHA FROM JULY 1, 1889, TO JULY 1, 1890.

Oak piling	linear feet	29,170	No. 9 wire	pounds	1,610
Brush	cords	5,120	No. 16 wire	do	4,490
Rock	cubic yards	18,800	Oak lumber	feet, B. M.	19,791
¾-inch cable	pounds	27,923	Pine lumber	do	173,297
⅝-inch cable	do	81,499	Telephone poles	linear feet	6,250

CALENDAR.

The several branches of work done during the year were between the following periods, all dates included:

Sinking piles: August 12 to September 21, 1889; April 24 to May 7, 1890.
Grading bank: August 12 to November 5, 1889; May 1 to June 1, 1890.
Rocking mattress and upper bank: August 22 to November 25, 1889; May 1 to June 19, 1890.
Mattress work: August 15 to November 4, 1889; April 28 to May 30, 1890.
Cutting brush: April 21 to May 23, 1890.
Building telephone line: September 23 to September 25, 1889.
Building ways: October 1 to November 13, 1889.
Pulling out boats: November 6 to November 29, 1889.
Calking and repairing boats: March 21 to May 3, 1890.
Launching boats: March 25 to May 5, 1890.
Towing with steamer *Capitola Butt*: July 22 to November 25, 1889; April 19 to June 21, 1890.

GENERAL CONDITION OF THE RIVER.

During the recent June rise, more or less cutting took place along the left bank between the boat-yard and the point above the Omaha and Council Bluffs bridge, and this has resulted in leaving the bank a very irregular shore-line. Should there be sufficient money available during the coming season to extend the revetment recently completed down the left bank a distance of 13,000 feet, the river in the immediate vicinity of Omaha will be in excellent shape, and the channel reasonably permanent in its course.

When the work already projected has been completed, attention should be given to the right bank of the river in the bend below Florence. This bank is of a sandy nature and cuts continuously except when the river is at a very low stage.

GAUGES.

The standard wire gauges at Sioux City, Blair, Omaha, and Plattsmouth have been checked regularly each month during the year, and corrections made when required.

The cable at Blair parted and was lost in the river April 2, 1890, and a new cable was substituted the following day.

The gauge-boards at Sioux City and Plattsmouth having become badly warped and the figures illegible, new boards were substituted during the month of May, which were made of seasoned oak with the figures burned on the wood.

SURVEY.

A survey was made from the head of the revetment to Union Pacific Railway Bridge, in December, 1889, and from Florence to the northwest dike in January, 1890.

The work was done by the regular winter force, consequently no additional expense was incurred.

FINANCIAL STATEMENT.

Cost of 13,004 *linear feet of revetment.*

Items.	Cost per foot of revetment.	Cost.
Sinking piles.		
Labor	$0.0805	$1,045.40
Material	0.2725	3,544.39
Fuel and supplies	0.0144	187.67
Subsistence	0.0255	332.75
	0.3929	5,110.21
Grading bank.		
Labor	0.1132	1,472.18
Fuel and supplies	0.0598	777.47
Subsistence	0.0507	659.20
	0.2237	2,908.85
Mattress, average width of 63 feet.		
Labor	0.2866	3,727.32
Brush	0.5383	7,001.19
Cable and fastenings	0.3223	4,192.16
Subsistence	0.1396	1,815.70
	1.2868	16,736.37
Rocking mattress and upper bank, anchoring cable.		
Labor	0.2950	3,836.99
Rock	1.5758	20,492.00
Subsistence	0.1558	2,026,96
	2.0266	26,355.95
Towing		
Labor	0.2476	3,220.27
Fuel and supplies	0.1651	2,146.93
Charter	0.2876	3,740.00
Towing—Continued.		
Subsistence	0.0763	992.0
	0.7766	10,099.29
Care of plant.		
Labor	0.1261	1,639.76
Subsistence	0.0457	595.24
	0.1718	2,235.00
Repairs and launching plant.		
Labor	0.0208	270.58
Material	0.1022	1,329.42
Subsistence	0.0386	501.72
	0.1616	2,101.72
Pulling out plant.		
Labor	0.0847	1,102.18
Supplies	0.0015	19.67
Subsistence	0.0383	498.75
	0.1245	1,620.60
General supplies	0.2700	3,511.75
Sundries	0.0639	831.26
Administration.		
Labor	0.4917	6,394.46
Subsistence	0.0183	238.07
	0.5100	6,632.53
Aggregate	6.0084	78,143.53

Additional expenditures.

Building ways:		
Labor	$1,992.71	
Material	3,367.87	
Subsistence	551.25	
		$5,911.83
Telephone line:		
Labor	65.40	
Material	264.35	
Subsistence	42.00	
		371.75
Warehouse:		
Labor	119.65	
Material	292.21	
Subsistence	31.50	
		443.36
Transferring plant from Kansas City, Mo		913.71
Material on hand		487.35
Expense of building graders Nos. 1 and 2 at St. Joseph, Mo., to June 1, 1890		1,407.11
Total		9,535.11

SUMMARY.

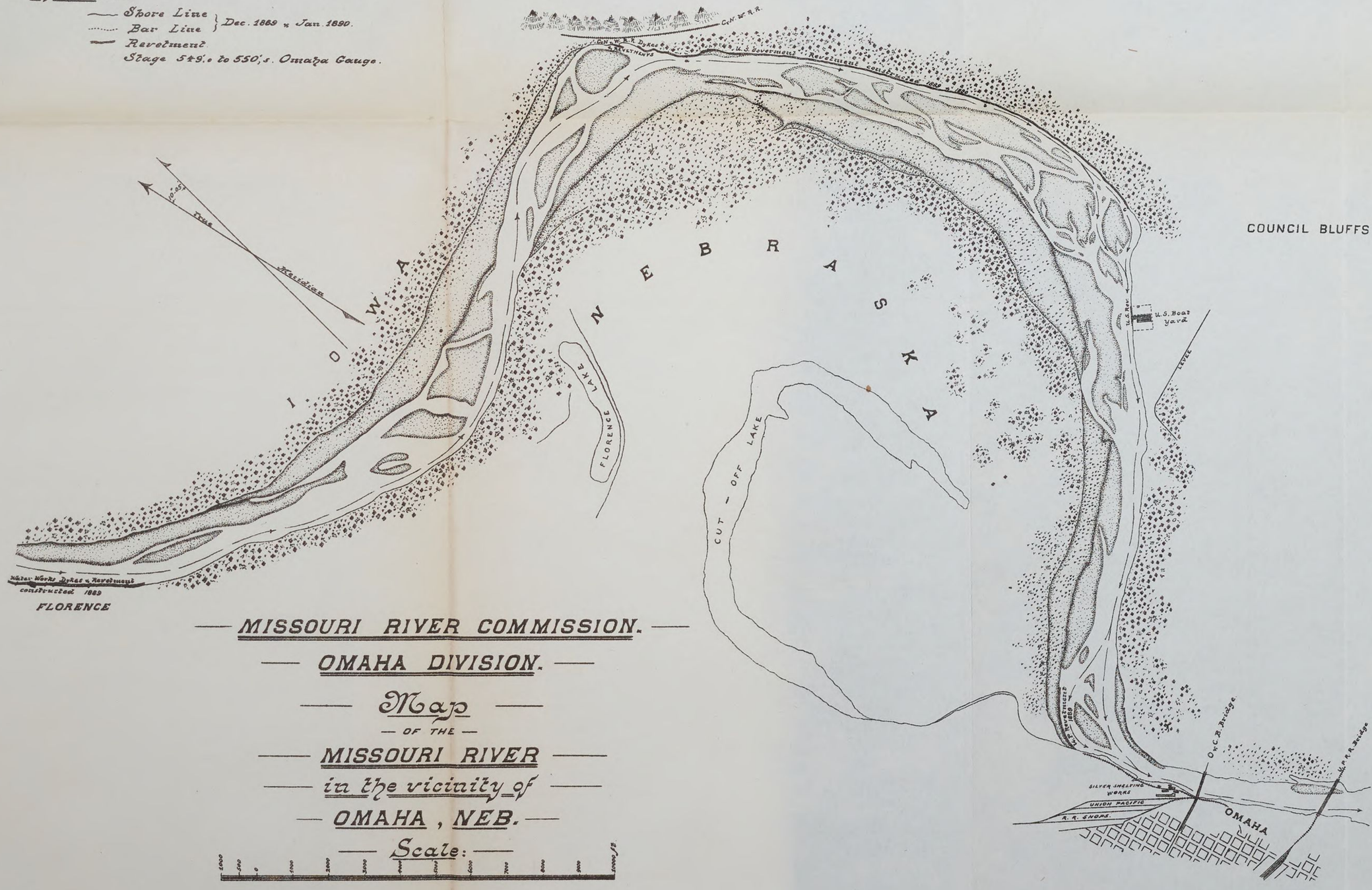
Cost of 13,004 linear feet revetment	78,143.53
Sundry expenditures	9,535.11
Total	87,678.64



annual report for 18

— References —

Shore Line
Bar Line } Dec. 1889 & Jan. 1890.
Revetment
Stage 549.6 to 550.5 Omaha Gauge.



— MISSOURI RIVER COMMISSION. —

— OMAHA DIVISION. —

— Map —

— OF THE —

— MISSOURI RIVER —

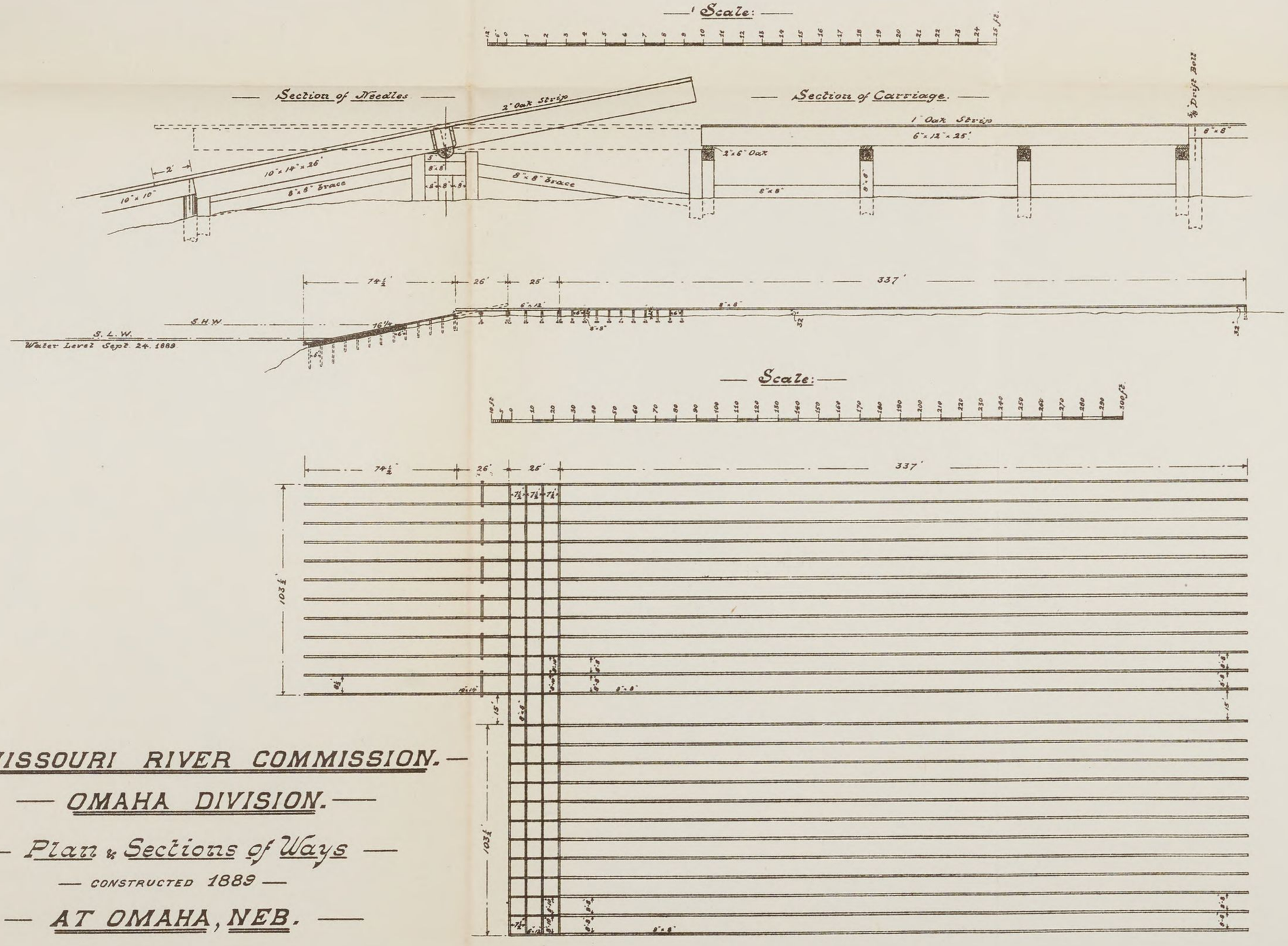
— in the vicinity of —

— OMAHA, NEB. —

— Scale: —

1000 500 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 ft.

To accompany annual report for 1890 of Chas. F. Potter, Division Engineer.



To accompany annual report for 1890 of Chas. F. Potter, Division Engineer.

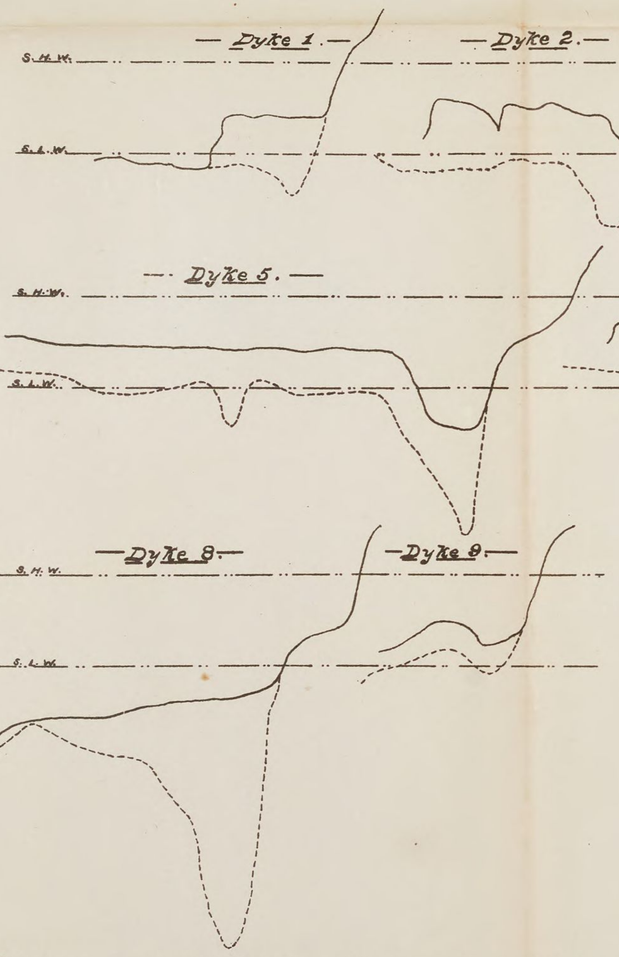
— AT OMAHA, NEB. —

— CONSTRUCTED 1883 —

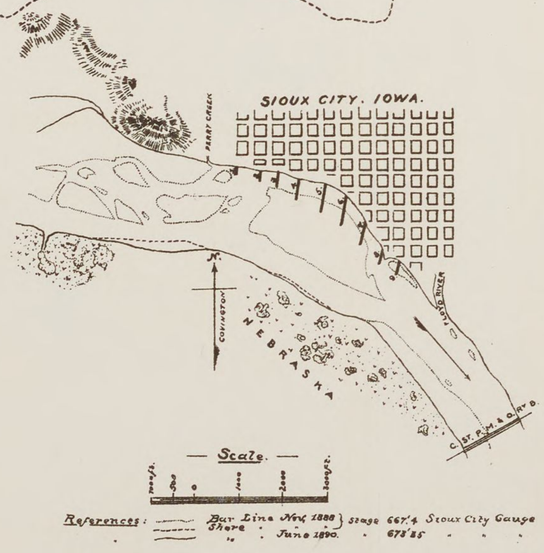
— PLANS & SPECIFICATIONS OF LOCKS —

— OMAHA DIVISION. —

— MISSOURI RIVER COMMISSION. —



References: ——— Surveyed June 20, 1890. Stage 672. Sioux City Gauge
- - - - - - April 11, 1889. " 668.35 " " "



References: ——— Bar Line Nov. 1888 } Stage 667.4 Sioux City Gauge
- - - - - - Shore " June 1890. " 673.85 " " "

MISSOURI RIVER COMMISSION.

OMAHA DIVISION.

Sketch & Partial Cross Sections

OF THE

MISSOURI RIVER

on line of Dykes

constructed May, June, & July, 1889.

SIOUX CITY, IA.

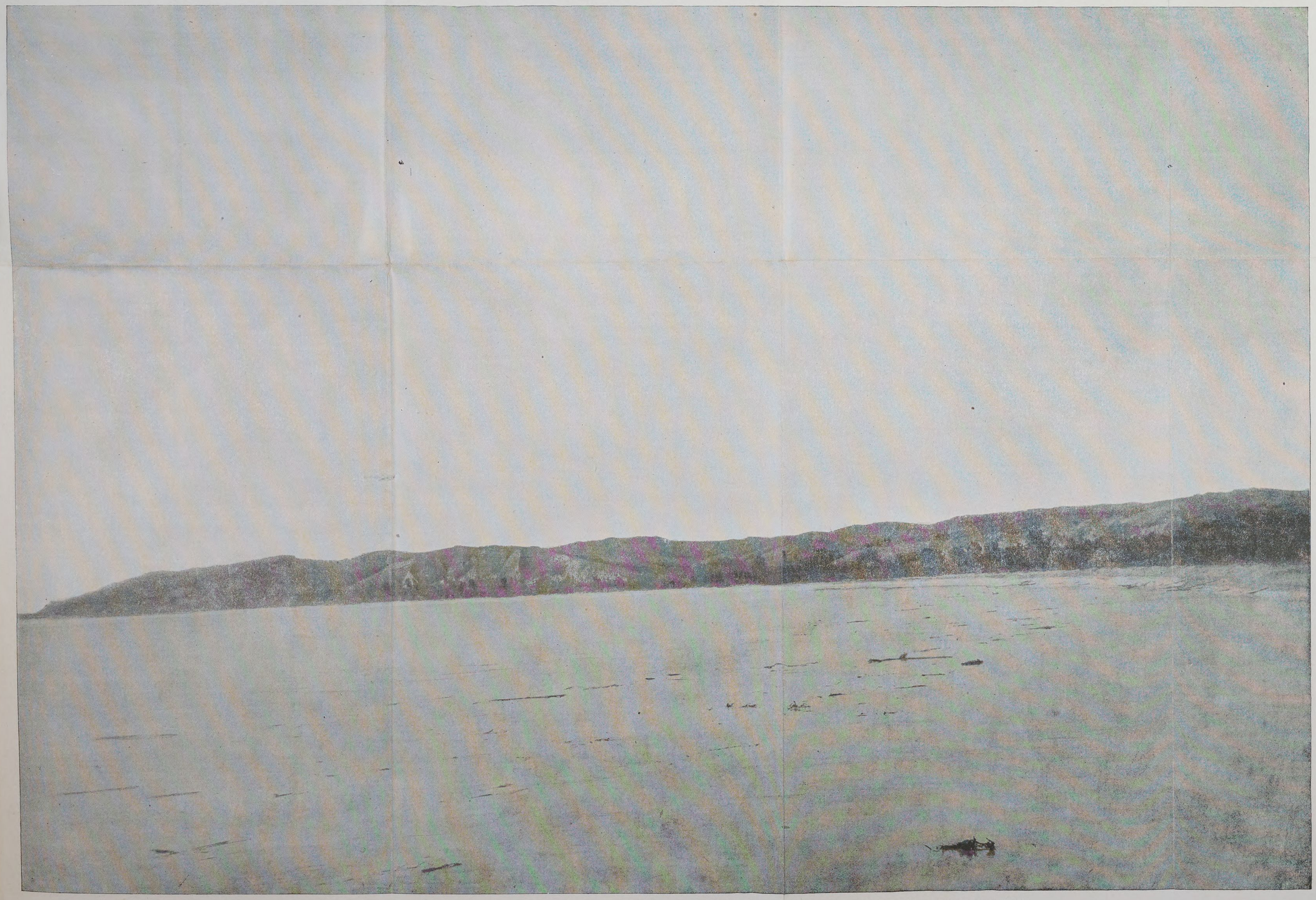
Horizontal Scale:

100 ft. 50 0 100 200 300 400 600 ft.

Vertical Scale:

10 ft. 5 0 10 20 30 40 50 ft.

To accompany annual report for 1890 of Chas. F. Potter, Division Engineer



VIEW OF REVETMENT AT OMAHA, NEBRASKA, CONSTRUCTED 1889 AND 1890, LOOKING UPSTREAM FROM A POINT ONE-HALF MILE ABOVE THE UNITED STATES BOAT-YARD. OMAHA GAUGE, 555.6.



VIEW OF REVETMENT AT OMAHA, NEBRASKA, CONSTRUCTED 1889 AND 1890, LOOKING DOWNSTREAM FROM THE C., N. W. RY. DIKES. OMAHA GAUGE, 555.80.



UNITED STATES WAYS AND BOAT-YARD AT OMAHA, NEBRASKA, CONSTRUCTED NOVEMBER, 1889.

I wish to acknowledge the valuable services of Assistant A. B. Ross, who had immediate charge of all work of construction.

I am, Colonel, very respectfully, your obedient servant,

CHAS. F. POTTER,
Division Engineer.

Lieut. Col. CHARLES R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

C 1.

ANNUAL REPORT OF MR. CHARLES F. POTTER, DIVISION ENGINEER.

OMAHA, NEBR., *June* 28, 1890.

COLONEL: I have the honor to submit the following report of operations under my charge on the Missouri River, at Sioux City, Iowa, for the fiscal year ending June 30, 1890.

At the beginning of the present fiscal year there yet remained a small amount of work in order to complete the dikes constructed in front of the city, previous to June 30, 1889. This work which consisted in placing 200 cubic yards of rock on the foot-mat, and in bracing the piles, was completed July 15, 1889. The Sioux City office was then closed, and the force transferred to Omaha.

The plant was towed to Omaha by the steamer *W. P. Bishop,* early in the month of July.

The tow-boat and six barges, which had been chartered, were delivered to the owners on July 13, 1889.

The results obtained at Sioux City have not been as marked as anticipated. While the dikes have successfully kept the channel out of the Sioux City bend, owing to the continued low stage of the river very little deposit had taken place in the bend until quite recently. On June 7, 1890, the river reached the highest stage since the dikes were constructed, the Sioux City gauge reading 475.65, or 8 feet above standard low water. Since that time the filling has been rapid and very satisfactory. The accompanying sketch of partial cross-sections shows the deposit from the time the dikes were commenced to June 20, 1890.

The right bank above and below Covington, Nebr., cut slowly but constantly throughout the greater part of the year, and since the high water of June 7, 1890, the bank has been caving in at a rapid rate. The maximum normal cutting, during the year, was 240 feet.

Survey was made June 16 and 17, 1890, of about 2 miles of river along the Sioux City front, and the change in the Nebraska shore is shown on the accompanying map.

In order that the relative elevations of the zero of the present Standard gauge and that of the old Ferry Creek gauge might be obtained, the slope has been taken between the two points at different stages of river, with the following results:

Date and time.	Elevation of water surface at Perry Creek.	Elevation of water surface at Standard gauge.	Slope.
1890.	*Feet.*	*Feet.*	*Feet.*
April 28, 12 m	669.80	668.80	1.00
May 21, 5.50 p. m	672.40	671.00	1.40
May 22, 12 m	672.30	670.98	1.32
June 19, 6 p. m	673.00	671.90	1.10
June 20, 6 p. m	674.50	673.35	1.15
June 21, 6 p. m	675.10	673.95	1.15

FINANCIAL STATEMENT.

Dike construction:		
Labor	$371.60	
Rock	44.08	
		$415.68
Towing:		
Labor	195.18	
Fuel and supplies	165.75	
Charter	520.00	
Subsistence	32.30	
		913.23
Care of plant:		
Labor		422.20
Repairs to plant:		
Labor		2,954.78
Launching plant:		
Labor		555.53
Surveys		34.33
Sundries		51.40
Constructions of Graders Nos. 1 and 2 at St. Joseph, to June 1, 1890:		
Labor		3,122.97
Administration		1,300.37
		9,770.49

I am, Colonel, very respectfully, your obedient servant,

CHAS. F. POTTER,
Division Engineer.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

APPENDIX D.

ANNUAL REPORT OF MR. S. WATERS FOX, DIVISION ENGINEER.

MISSOURI RIVER COMMISSION,
OFFICE OF DIVISION ENGINEER,
St. Joseph, Mo., June 30, 1890.

COLONEL: I have the honor to submit the following report, and the accompanying illustrations of the operations under my charge on the St. Joseph division, during the fiscal year ending June 30, 1890:

NEBRASKA CITY.

The approved project for the expenditure of the funds available for the improvement of the Nebraska City Reach, contemplated the construction of a revetment extending from A to B on the accompanying map.

An office was opened at Nebraska City in the latter part of July.

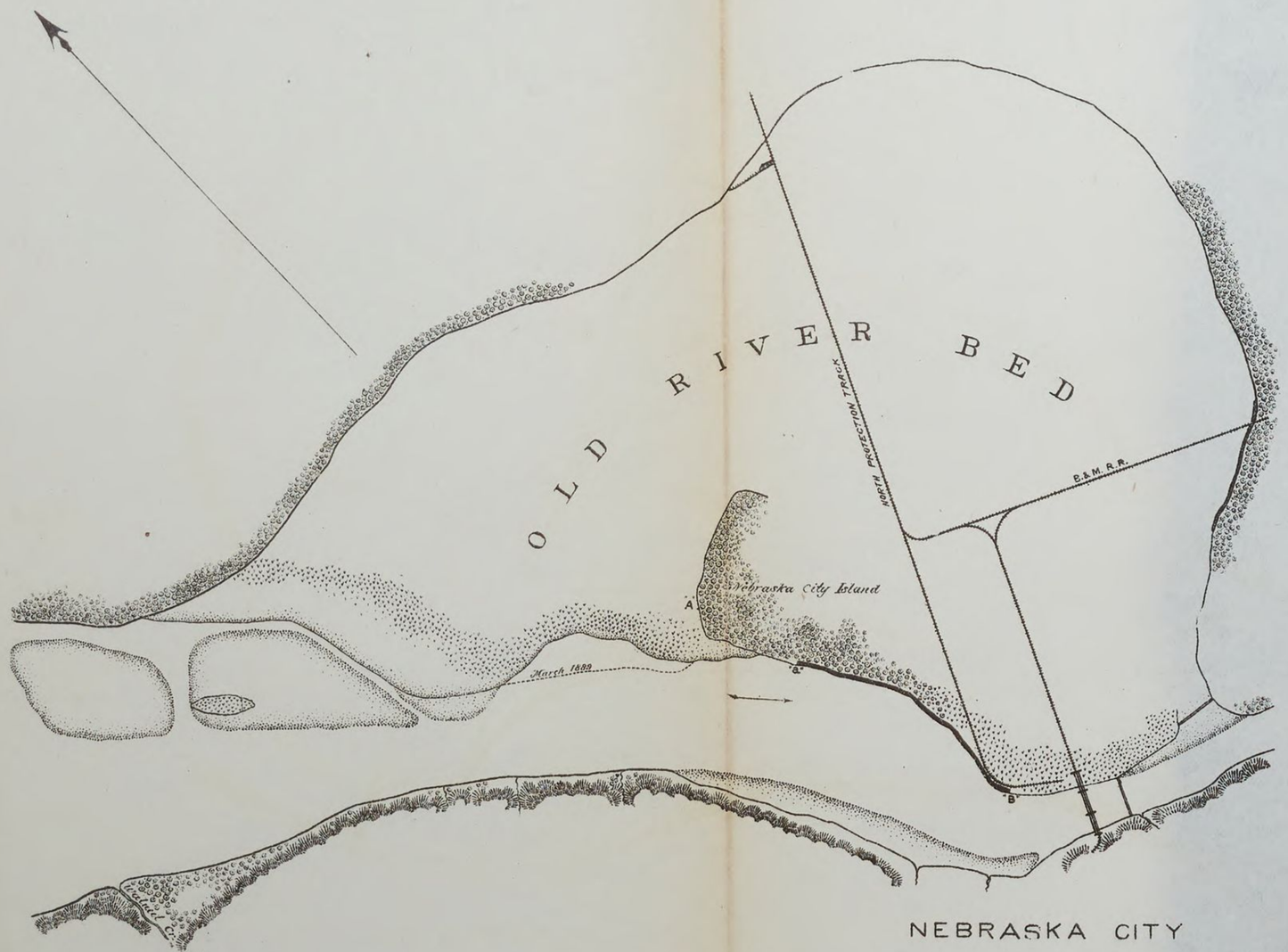
Bank grading was begun August 9, 1889, at a point about 700 feet above "a" (on the map).

Weaving mattress was begun August 17, 1889, at "a," about 700 feet below the head of the graded bank; this on account of shoal water. It was finished October 7, 1889. The total mattress woven was 4,908 linear feet, or 515,093 square feet. The total length of bank protected was 4,810 feet.

The minimum width of the low-water mattress was 65 feet. Rounding the point above B, the low-water width was increased to 90 feet.

The total quantity of rock used was 9,416.58 cubic yards. Of this amount 500 cubic yards were procured from the work put in by the railroad company to protect the bridge approach; the balance was purchased in open market at a cost of $1.24 per cubic yard, delivered on barges at Nebraska City, Nebr.

The brush used (3,021.8 cords) was procured by hired labor at a cost of $1.67 per cord, delivered at the works.



MISSOURI RIVER COMMISSION.

ST. JOSEPH DIVISION.

MAP

OF THE

MISSOURI RIVER

IN THE VICINITY OF

NEBRASKA CITY, NEB.,

SHOWING

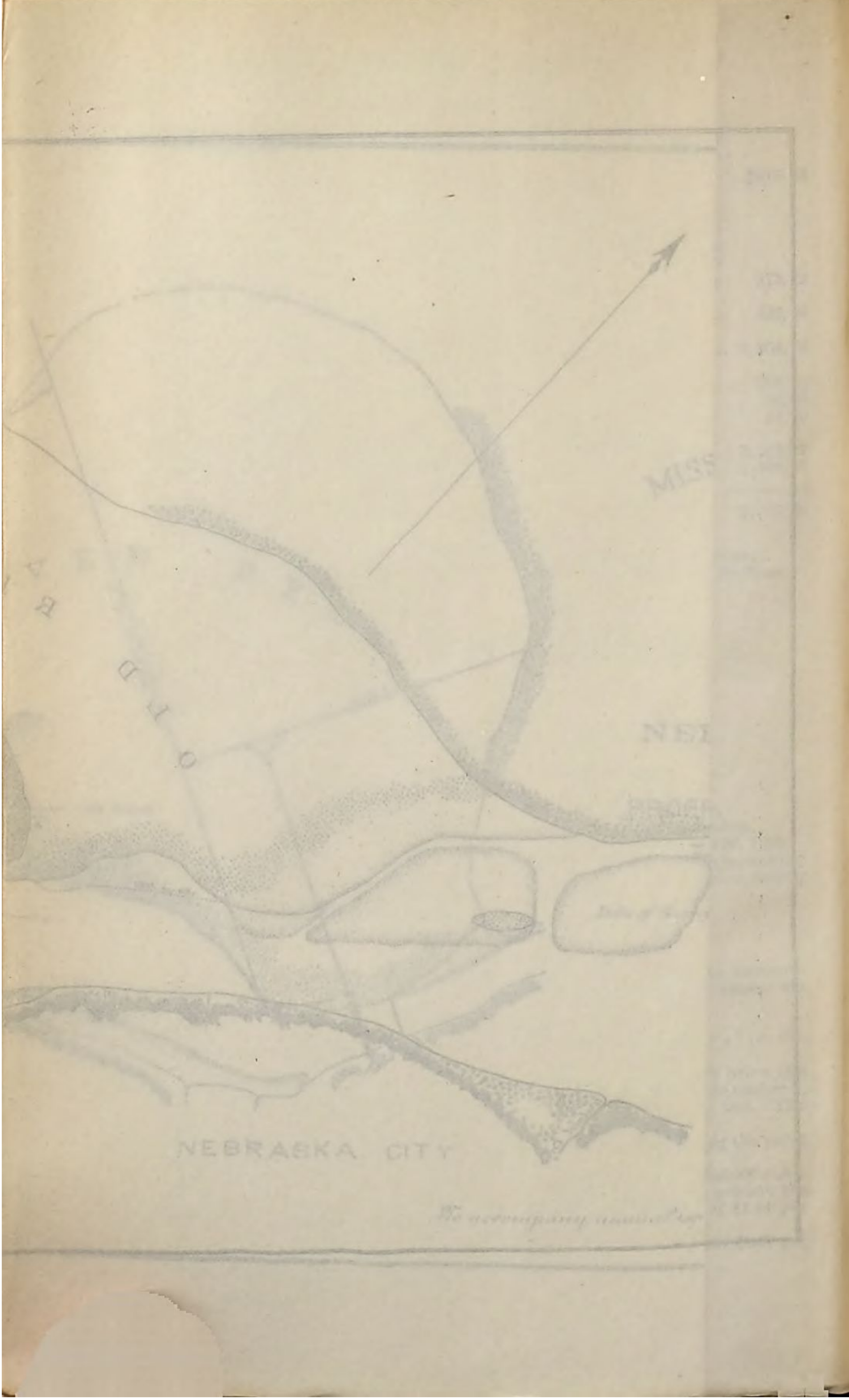
PROGRESS OF IMPROVEMENTS.

Scale:

1000 500 0 1000 2000 3000 4000 5000 ft.

Date of Survey: May 1890. *Stage of River: 2.36 ft. above S.L.W.*

To accompany annual report for 1890 of S. W. Fox, Division Engineer.


NEBRASKA CITY

The specifications which have governed the construction of revetment on the St. Joseph Reach were closely followed. The following is an exhibit of the cost in detail of the work:

Cost exhibit in detail of 4,810 *linear feet of revetment, Nebraska City,* 1889.

Classification and extent.	Cost per unit.	Cost each item.	Cost per linear foot.	Cost of 4,810 feet revetment.
Procuring 3,021.8 cords brush:				
Stumpage	$0.0725	$219.30		
Cutting	.2926	884.33		
Binding: Labor, $454.25; material, $157.05	.2023	611.30		
Loading wagons	.0647	195.47		
Hauling	.2722	822.67		
Loading barges, 1,840 cords	.2314	425.70		
Subsistence, 30,218 cords	.1981	598.80		
Towing 1,840 cords:				
Labor	.4216	775.95		
Fuel	.2336	430.00		
Subsistence	.0564	103.82		
	.....	5,067.34	$1.0535	$5,067.34
Procuring 8,916.58 cubic yards rock:				
On barge (contract)	1.2363	11,023.89		
Towing:				
Labor	.0482	429.80		
Fuel	.0266	237.20		
Subsistence	.0064	57.48		
	1.3175	11,748.37	2.4425	11,748.37
Weaving 4,908 linear feet mattress, lap 98 feet:				
Labor	.6222	3,053.78		
Subsistence	.2495	1,224.95		
	.8715	4,278.73	.8895	4,278.73
Anchoring 4,908 linear feet mattress:				
Labor	.1238	607.57		
Strand, $\frac{3}{8}$-inch	.2248	1,103.40		
Cable, $1\frac{1}{4}$-inch	.0522	255.68		
Clips	.0104	51.30		
Subsistence	.0498	244.51		
	.4610	2,262.46	.4703	2,212.46
Hydraulic grading, 10,713 cubic yards:				
Labor	.0296	317.68		
Fuel	.0065	69.33		
Subsistence	.0115	123.32		
	.0476	510.33	.1061	510.33
Hand grading, 988 linear feet:				
Labor	.3034	299.83		
Subsistence	.1230	121.47		
	.4264	421.30	.0876	421.30
Placing rock, 9,416.58 cubic yards:				
Labor	.0852	801.95		
Subsistence	.0342	322.42		
	.1194	1,124.37	.2338	1,124.37
Total	.....	.....	5.2833	25,412.90

It having been decided to winter the fleet on the Nebraska City Reach, launching and storage ways were built on the left bank a short distance above the bridge. The fleet, consisting of twenty-eight pieces, was gotten out of the river by November 22, viz, 13 barges, 25 by 100 feet; 7 barges, 16 by 65 feet; 3 quarter-boats, Nos. 1, 5, and *Pappoose*; 1 hydraulic pile-sinker, No. 7, and cross-boat; 2 mattress-boats, Nos. 3 and 5; 1 steamer, *Sabrina*.

The following is a statement of the cost of construction of—

Boat-ways:		
Labor		$1,544.28
Subsistence		309.00
Material:		
Lumber	$860.40	
Piling	526.25	
Hardware	120.19	
		1,506.84
Total cost		3,360.12

Miscellaneous data:

Top of yard-ways, 15 feet above slope launching-ways.
Top of yard-ways, about 4 feet above ground.
Slope of launching-ways, 1–5.
Yard-ways, 8 by 8 inch pine.
Needles, 10 inches by 14 inches by 26 feet, pine.

Statement of cost of pulling out boats.

Labor	$595.25
Subsistence	237.00
Supplies	10.00
Total	842.25
Cost per piece	30.08
Cost per ton	.39

This work accomplished, the force was reduced to Assistant Jos. C. Meredith and two watchmen.

March 12 work was begun making necessary repairs to that portion of the fleet that would be used on the Rulo Reach. The repairs to the wooden hulls were confined chiefly to a thorough recalking. The engines and boiler of the *Sabrina* were overhauled. Guards were put on her, extending back to the wheel-houses; the square head thus made adds very much to the efficiency of the steamer as a tow-boat. These repairs were finished in April, and the fleet, consisting of the following pieces, was launched and taken to Rulo, viz: Steamer *Sabrina;* 3 quarter-boats, Nos. 1, 5, and *Pappoose;* 2 mattress-boats, Nos. 3 and 5; 1 pile-sinker, No. 7; 8 barges, 25 by 100 feet; 1 barge, 16 by 65 feet.

The following is a statement of cost of repairs:

General repairs to plant.

Labor			$913.55
Subsistence			240.00
Material:			
Lumber, etc	$308.00		
Oakum, pitch, etc	88.40		
Hardware, etc	45.30		
		441.70	
			$1,595.25
Repairs and alterations to steamer *Sabrina:*			
Labor			521.33
Subsistence			71.90
Material:			
Lumber	$44.92		
Angle-iron, rivets, etc	102.91		
Boiler-tubes, etc	51.77		
		199.60	
Total cost of repairs			2,388.08

Statement of cost of launching.

Labor	$235.15
Subsistence	60.00
Total	295.15
Cost per piece	19.68
Cost per ton	.20

The office at Nebraska City was then closed and the property at the yards left in care of two watchmen.

It is proposed to expend the available balance of the allotment in the construction of revetment from A to "a" as soon as the river shall have cut back to the main bank.

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MISSOURI RIVER COMMISSION.

ST. JOSEPH DIVISION.

MAP

OF THE

MISSOURI RIVER

IN THE VICINITY OF

RULO, NEB.

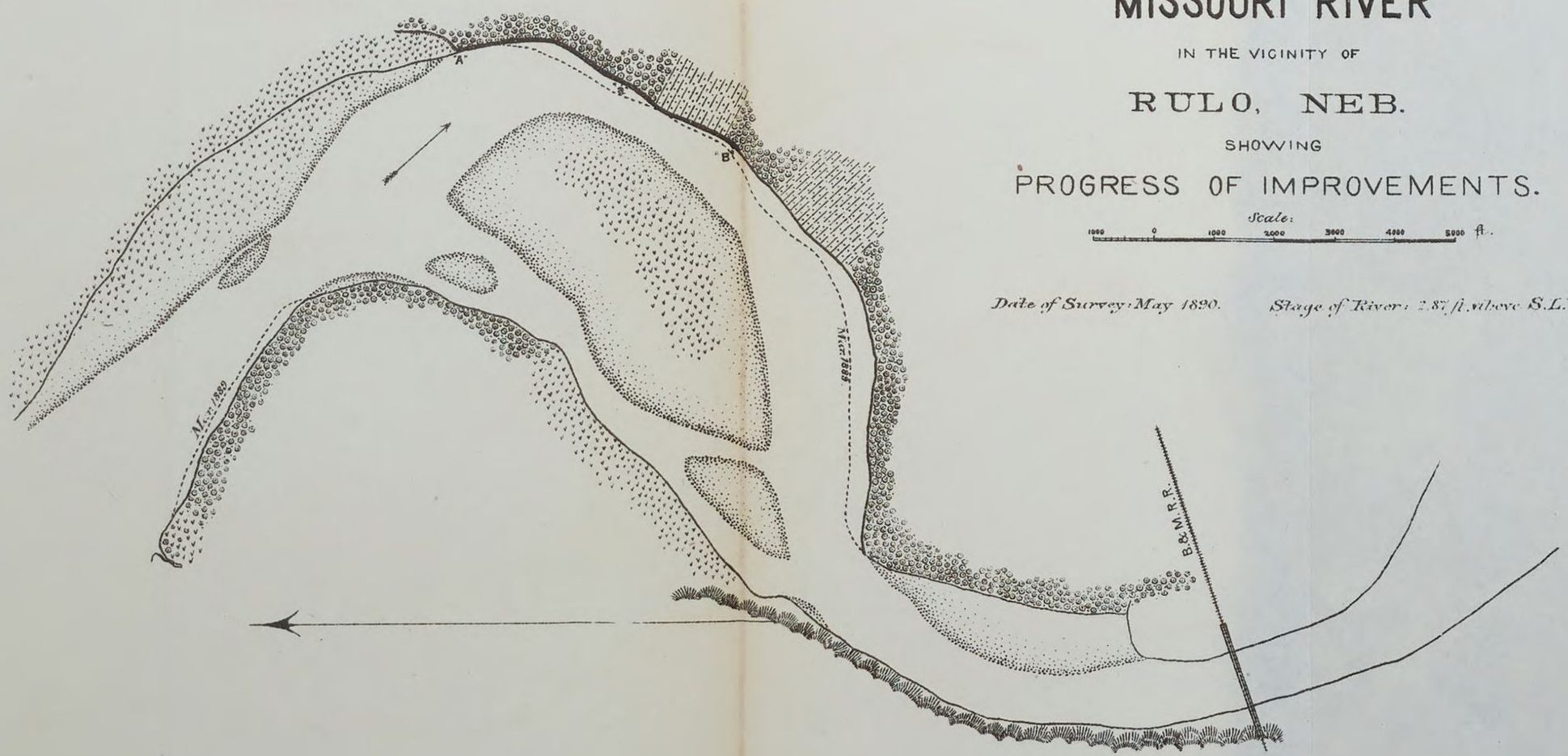
SHOWING

PROGRESS OF IMPROVEMENTS.

Scale:

1000 0 1000 2000 3000 4000 5000 ft.

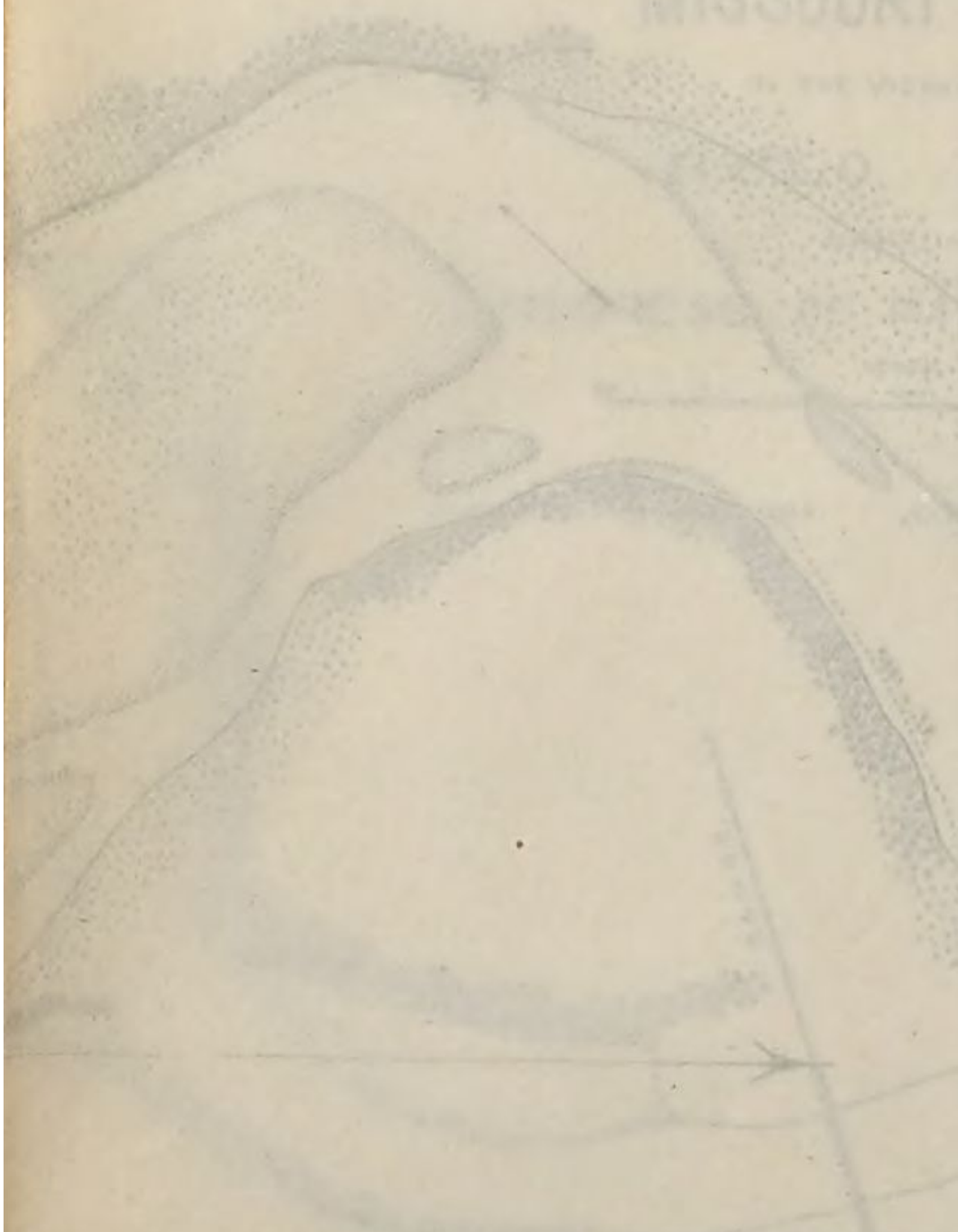
Date of Survey: May 1890. *Stage of River: 2.87 ft. above S.L.W.*



RULO

To accompany annual report for 1890 of S. W. Fox, Division Engineer

Eng 90


MISSOURI

I beg leave to refer to my project, dated April 15, 1889, for the improvement of the Nebraska City Reach, and to call attention to the danger, as explained therein, of loss to the work already done by flanking from above.

RULO.

In accordance with the instructions contained in your letters, dated July 17 and August 24, 1889, respectively, I submitted, under date of September 10, 1889, a project with estimates of cost of improving Missouri River in the vicinity of Rulo, Nebr.; also a project for the expenditure, in conformity with the approved plans of the Commission, of the available balance of the current appropriation.

The latter contemplated the construction of 3,500 linear feet of standard revetment on the left bank above Rulo, from point A to "a" (see accompanying map).

March 24, 1890, a small party was put to work clearing the bank of undergrowth and timber.

A quarry was opened near Arago, Nebr., April 10.

The steamer *Sabrina* arrived on the reach April 28 with the first tow of plant from Nebraska City, consisting of one rock barge and jet pile-sinker No. 7, the latter for use as a hydraulic grader.

Bank grading was begun at once and continued with but little interruption till June 13. Five thousand one hundred and fifty-three linear feet of bank were graded, involving the removal of 36,854 cubic yards of earth at the unusually low cost of 1.6 cents per cubic yard.

Weaving mattress was begun May 7, and when about two-thirds of the projected length had been finished, it became apparent that the cost of the work would fall considerably below the estimates. Authority was therefore obtained to extend the work proportionately.

Owing to a failure of the boiler of the steamer *Sabrina* (a crack in the flue-sheet), it became necessary to suspend work June 27 and 28. On this account the weaving of the mattress was not finished until July 2.

The total mattress woven was 4,922 linear feet, or 538,161 square feet. The length of bank protected was 4,922 feet. (See map, "A" to "B.")

The increase in the length of revetment made it necessary to purchase 4,000 cubic yards of rock, and to increase the fleet with three large barges from St. Joseph. These were delivered at Rulo in two tows by steamer *A. Saltzman* at a cost of $150.

The following exhibit of the cost of the revetment includes the two days' work in July, 1890.

It is estimated that when finished the revetment will have cost $4.23⅓ per linear foot.

After the completion of the Rulo work the fleet and all other property will be taken to Nebraska City, and the Rulo office closed.

Cost exhibit in detail of 4,922 feet of revetment, Rulo, Nebraska, 1890.

Classification and extent.	Cost per unit.	Cost each item.	Cost per linear foot.	Cost of 4,922 feet revetment.
Procuring 3,297.8 cords brush:				
Stumpage	$0.0800	$126.64		
Cutting	.2418	797.54		
Binding, labor, and material	.1805	595.27		
Hauling	.2855	941.93		
Barging	.1531	347.85		
Subsistence	.1265	200.00		
Towage:				
Labor	.0651	148.02		
Fuel	.0209	47.50		
Subsistence	.0176	40.00		
		3,244.75	$0.6592+	$3,244.75
Procuring 6,988.7 cubic yards rock:				
Purchased 2,194.1 cubic yards on barge	1.3750	3,016.89		
Procured by hired labor, 4,794.6 cubic yards.				
Stripping	.2051	983.70		
Drilling	.1797	861.86		
Breaking	.1349	647.22		
Barging	.0728	349.05		
Towage:				
Labor	.0847	592.08		
Fuel	.0271	190.00		
Subsistence	.0228	160.00		
	.7271	6,800.80	1.1817+	6,800.80

Cost exhibit in detail of 4,922 *feet of revetment, Rulo, Nebraska,* 1890—Continued.

Classification and extent.	Cost per unit.	Cost each item.	Cost per linear foot.	Cost of 4,922 feet revetment.
Weaving 4,922 linear feet of mattress :				
Labor	$0.4990	$2,456.32		
Subsistence	.2370	1,166.67		
	.7360	3,622.99	$0.7360+	$3,622.99
Anchoring 4,922 linear feet of mattress :				
Labor	.0901	443.55		
Strand, ⅜ inch	.2404	1,183.52		
Cable, 1¼ inch	.0961	473.34		
Clips	.0040	20.00		
Subsistence	.0474	233.33		
	.4780	2,353.74	.4782+	2,353.74
Hydraulic grading 36,854 cubic yards :				
Labor	.0099	365.42		
Fuel	.0035	132.00		
Subsistence	.0026	97.92		
	.0160	595.34	.1209+	595.34
Placing rock, 6,988.7 cubic yards :				
Labor	.1092	763.60		
Subsistence	.0313	218.75		
	.1405	982.35	.1995+	982.35
Totals			3.5757+	17,599.97

Bill of cost of 4,922 *feet of revetment at Rulo.*

15,808 cords brush stumpage at 8 cents		$126.64
32,978 cords brush on barge		2,711.59
3,600 pounds binding wire at 4¾ cents		171.00
11,526 pounds wire strand at 5 cents	$576.30	
12,267 pounds wire strand at 4.95 cents	607.22	
		1,183.52
42,075 pounds 1¼ inch cable at 1⅛ cents		473.34
100 pounds clips at 20 cents		20.00
4,794.6 cubic yards rock procured by hired labor		2,841.83
2,194.1 cubic yards rock purchased at $1.37½		3,016.89
Labor and subsistence, ballasting		982.35
Labor and subsistence, weaving and anchorage		4,299.87
Labor, fuel, and subsistence, hydraulic grading		595.34
Labor, fuel, and subsistence, towage		1,177.60
Total cost of mat		17,599.97
Estimated 1,800 cubic yards rock, contract in place	$2,835.00	
Estimated 500 cubic yards rock, hired labor in place	400.00	
		3,235.00
Total cost Rulo revetment		20,834.97

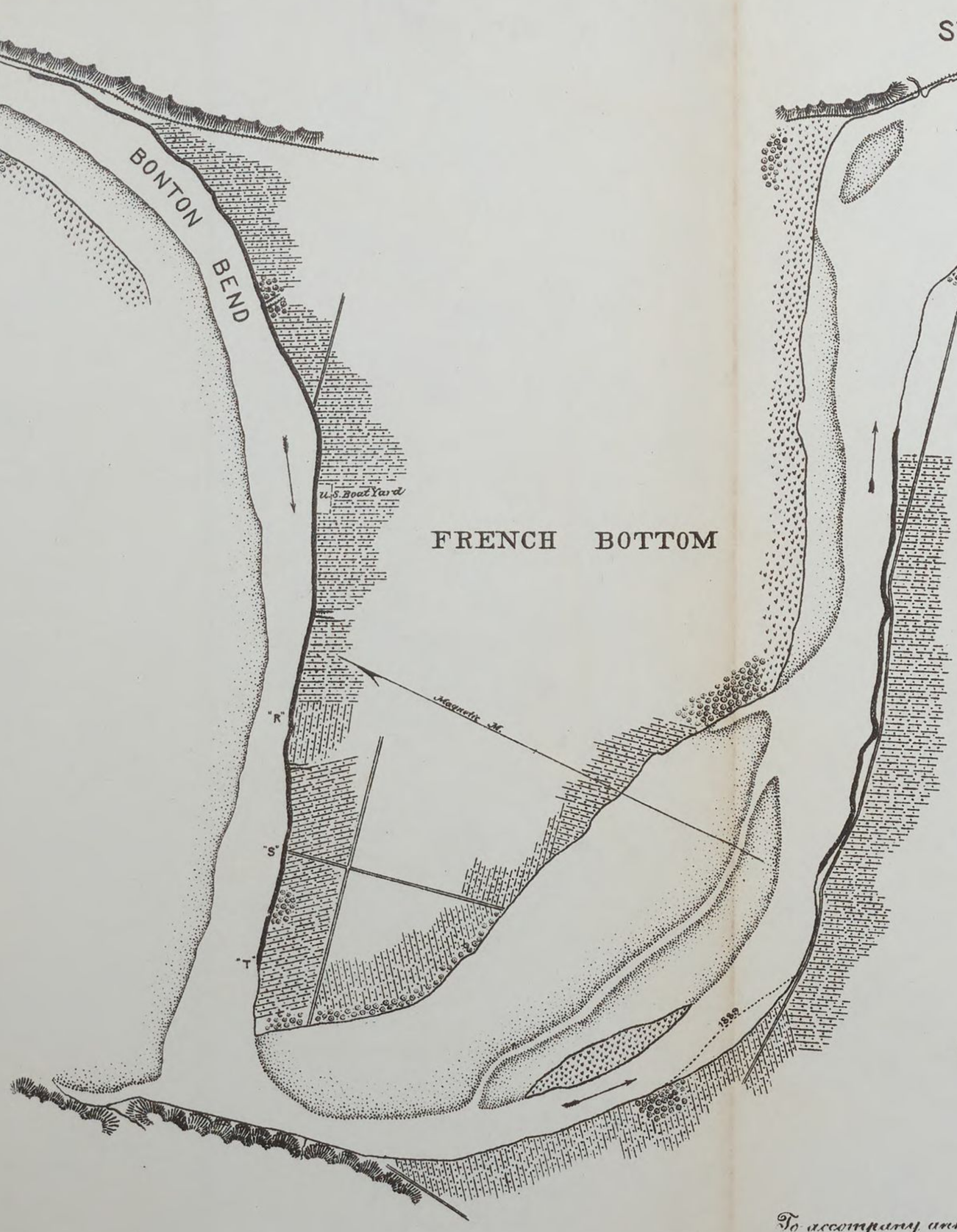
Miscellaneous data and elements of cost exhibit.

Linear feet of mattress		4,922
Square feet of mattress		538,161
Total cost		$17,599.97
Cost per foot		$3.5755
Cost per square, *i. e.*, 100 square feet		$0.032703
Meals issued to work		15,384
Subsistence cost		$2,116.67
Subsistence cost per capita per diem :		
Labor	$0.1177	
Stores	.2950	
		$0.4127

ST. JOSEPH, MISSOURI.

The operations at St. Joseph consisted in the completion of the revetment begun June, 1889, in Bon Ton Bend ; some repairs to the revetment constructed in 1885 ; the care of, and repairs to plant, and surveys.

The new revetment in Bon Ton Bend was completed August 14, 1889. The total new mattress woven during the season was 4,713 linear feet, or 583,847 square feet; protecting 4,673 linear feet of bank (R to T, see map). Of this amount, 2,177 linear feet, from S to T, were woven between July 1 and 24, 1889.



MISSOURI RIVER COMMISSION.

ST. JOSEPH DIVISION.

MAP

OF THE

MISSOURI RIVER

IN THE VICINITY OF

ST. JOSEPH, MO.,

SHOWING

PROGRESS OF IMPROVEMENTS.

Scale:

1000 0 1000 2000 3000 4000 5000 ft.

Date of Survey: May 1890. *Stage of River: 1.53 ft. above S.L.W.*

To accompany annual report for 1890 of S. W. Fox, Division Engineer.

FRENCH BOTTOM
ST JOSEPH
NORTH BOTTOM
BEND

The total length of continuous revetment now in Bon Ton Bend is 19,332 feet, or about $3\frac{3}{8}$ miles.

The following is an exhibit of the cost in detail of the new work, viz:

Cost exhibit in detail of 4,673 *linear feet of revetment, St. Joseph,* 1889.

Classification and extent.	Cost per unit.	Cost each item.	Cost per linear foot.	Cost of 4,673 feet of revetment.
Procuring 8,030.1 cubic yards rock:				
Quarry privilege	$0.0100	$80.30		
Quarrying	.2827	2,270.11		
Stripping	.0653	524.36		
Constructing road	.0184	147.75		
Loading wagons	.0886	711.47		
Hauling	.1777	1,426.95		
Loading barges	.0919	737.97		
Powder	.0085	68.26		
Towing:				
Labor	.0487	391.07		
Fuel	.0407	326.82		
Procuring 1,217.79 cubic yards rock:				
Quarrying	.3079	374.96		
Loading barges	.1083	131.89		
Cost at work	1.2487	7,191.90	$1.5390	$7,191.90
Placing 8,993.89 cubic yards rock:				
Labor	.1332	1,197.99		
Subsistence	.0224	201.46		
Cost of placing	.1556	1,399.45	.2990	1,399.45
Total cost 8,993.89 cubic yards rock in place	.....	.....	1.8380	8,591.35
Procuring 2,773.82 cords brush:				
On stump	.1000	277.38		
Cutting	.3733	1,035.47		
Binding:				
Labor	.1839	510.10		
Material, wire	.0612	169.76		
Loading wagons	.0903	250.48		
Hauling	.4314	1,196.63		
Loading barges	.3239	898.44		
Towing:				
Labor	.0728	201.93		
Fuel	.0614	170.31		
Cost at work	1.6982	4,710.50		
Procuring 327.3 cords brush:				
On barge (contract)	1.1000	360.03		
Towing:				
Labor	.0728	23.83		
Fuel	.0614	20.09		
Cost at work	1.2342	403.95		
Total cost 3,101.12 cords brush	.....	.....	1.0944	5,114.45
Weaving 4,713 linear feet mattress:				
Labor	.6771	3,191.18		
Subsistence	.1696	799.55		
	.8467	3,990.73	.8540	3,990.73
Anchoring 4,673 linear feet mattress:				
Labor	.0942	440.20		
Subsistence	.0026	12.15		
Strand $\frac{3}{8}$ inches	.2256	1,054.23		
Cable $1\frac{1}{4}$ inches	.0942	440.19		
	.4166	1,946.77	.4170	1,946.77
Hydraulic grading, 32,086.5 cubic yards:				
Labor	.0136	436.38		
Fuel	.0027	86.63		
Subsistence	.0028	89.84		
	.0191	612.85	.1310	612.85
Total	.....	.....	4.3344	20,256.15

Two hundred and fifty-four cubic yards of rock were distributed on the old work at places where the rock had been displaced by ice and other causes.

In April a patch of mattress 190 by 75 feet was woven over a break in the Bon Ton revetment at a point about 2,000 feet below the Water Company's pumping station. The cost of the work is shown below.

Cost exhibit in detail of repairs to Bon Ton Revetment.

Classification and extent.	Cost per unit.	Cost each item.	Total cost.
Procuring 278.9 cubic yards rock:			
On cars, contract	$1.300	$362.57	
Unloading cars	.043	12.00	
Hauling	.336	93.725	
Cost at work	1.679	.....	$468.295
Procuring 90 cords brush:			
On stump	.150	13.50	
Cutting	.233	21.00	
Binding	.196	17.65	
Loading	.103	9.30	
Hauling	.553	49.775	
Unloading	.079	7.10	
Right of way	.056	5.00	
Cost at work	1.370	.....	123.325
Weaving and anchoring 190 linear feet mattress:			
Weaving	.634	120.40	
Placing rock	.333	63.266	
Transportation of cable	.049	9.29	192.956
Total cost constructing 190 feet revetment	4.13	.....	784.576

The steamer *Sabrina* continued in service on St. Joseph reach until August 13, at which time she was ordered to Nebraska City. She performed all the towing service on that reach. She has been in service this season since April. The number of days she was in service on the Nebraska City reach was 73; the number of miles run, 1,923; the number of tons towed, 20,400.

The number of days in service on the Rulo reach, and between Nebraska City and Rulo, was 64; the number of miles run, 2,117; the number of tons towed, 31,735.

The average cost of the service per ton per mile was $0.0082.

The steamer *Alert* was engaged in towing plant from Atchison to St. Joseph, and from St. Joseph to Nebraska City, until the latter part of September, when she was given orders to report to Mr. Yonge at Kansas City, Mo.

In September that portion of the fleet that was to be wintered in this vicinity was pulled out and placed on the ways in French Bottom; there were twelve pieces in all, as follows, viz: United States steamer *Thetis;* hydraulic pile-sinker No. 13, and cross-boat; seven barges, 25 by 100 feet; two barges, 16 by 65 feet.

This work was finished September 20; the entire force, with the exception of two watchmen, was then discharged.

REPAIRS TO PLANT.

Two small barges that had been repaired in June were launched in July. A small force of carpenters was kept at work on repairs until August 9.

In March, 1890, a force of carpenters was put to work rebuilding for use on the Omaha division the hulls of hydraulic graders Nos. 1 and 2; also repairing those pieces that were to be used on the St. Joseph reach during the season. In addition to the small hulls referred to above, and one of the hydraulic graders, three large barges were repaired and launched; the latter for use on the Rulo reach. The second grader will be finished and launched early in July.

ATCHISON.

No construction work was done on the Atchison reach during the fiscal year.

Two surveys were made. A map of the last one accompanies the report.

The rectification effected by the works finished a year ago has been completed; but owing to the prevailing low stage of the river the deposits below the dikes have been small.

MISSOURI RIVER COMMISSION.

ST. JOSEPH DIVISION.

MAP

OF THE

MISSOURI RIVER

IN THE VICINITY OF

ATCHISON, KAN.,

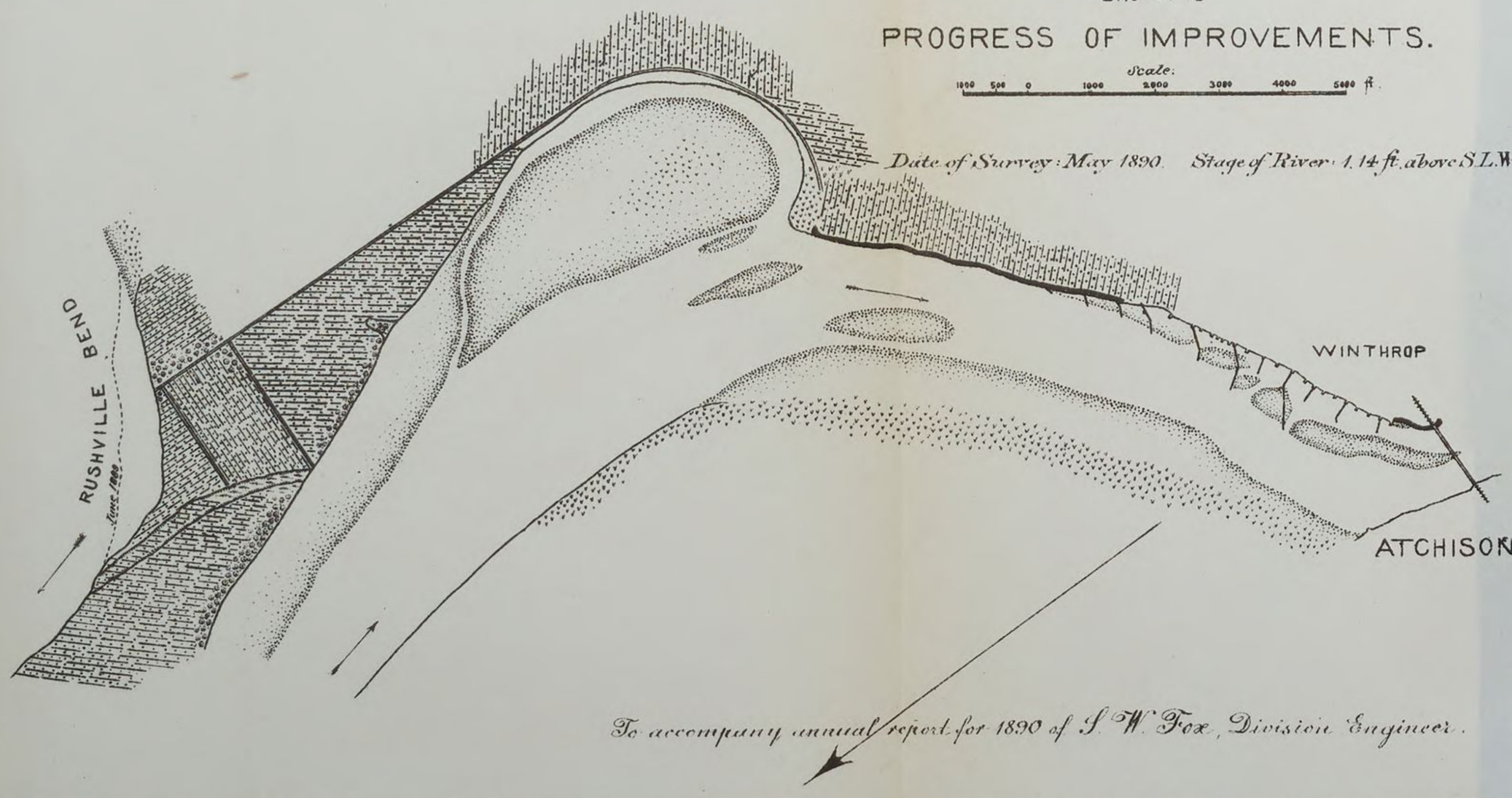
SHOWING

PROGRESS OF IMPROVEMENTS.

Scale:

1000 500 0 1000 2000 3000 4000 5000 ft.

Date of Survey: May 1890. *Stage of River: 1.14 ft. above S.L.W.*



To accompany annual report for 1890 of S. W. Fox, Division Engineer.

MISSISSIPPI RIVER COMMISSION
VICKSBURG DIVISION
MAP
OF THE
MISSISSIPPI RIVER
FROM
VICKSBURG, MISS.
TO
ARKANSAS POST, ARK.
SHOWING
REVETMENTS
AND
OTHER WORKS
FOR THE
IMPROVEMENT OF THE RIVER
AND
PROTECTION OF THE BANKS
1907
MUSHMILLE BEND

It will be noticed that the erosion of the left bank at Rushville Bend has reduced the width of the neck which separates it from McQueen's Bend to about 1,700 feet between main banks at the narrowest place.

To prevent an ultimate cut-off at this point Rushville Bend should be revetted and the reach above rectified, as projected in my letter dated July 14, 1889.

SURVEYS.

The approaches to the bridges at Atchison and St. Joseph were surveyed, and diagrams showing the data were transmitted under dates of April 25 and May 6, 1890.

Partial shore-line surveys of each reach of the division were made in June.

Work on the permanent bench-mark survey was suspended July 9, 1889. Lines No. 84 and 83 were established.

All of the field-notes and a list of the P. B. M.'s describing their locations were sent in November 29, 1889.

The gauges on the St. Joseph division were inspected and verified once a month. A history of each gauge was compiled and submitted under date February 17, 1890.

Very respectfully, your obedient servant,

S. WATERS FOX,
Division Engineer.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

APPENDIX E.

ANNUAL REPORT OF MR. S. H. YONGE, DIVISION ENGINEER.

MISSOURI RIVER COMMISSION,
OFFICE OF DIVISION ENGINEER,
Kansas City, Mo., June 30, 1890.

COLONEL: I have the honor to submit a report of the operations conducted under my charge on the Kansas City Division, Improvement of the Missouri River, during the fiscal year ending June 30, 1890. These operations consisted in completing the repairs to plant stored at Quindaro boat-yard; the construction of revetments in the vicinities of Leavenworth, Kans., and Arrow Rock, Mo.; extending and making repairs to the Harlem and Kansas City dikes; making repairs to the revetment in Upper Kaw Bend; constructing revetment at the foot of Kaw Bend, herein referred to as Kaw Point Revetment; constructing dikes at Miami, Mo.; making surveys of the reaches of the river where improvement works were being carried on; inspecting water-gauges between Fort Leavenworth, Kans., and the mouth of the Missouri River; making special surveys of the Missouri River at bridge-crossings, etc.

REPAIRS TO PLANT.

The work of repairing the plant, which was begun in October, 1888, was completed October 25, 1889, and comprised the following pieces repaired since the close of the last fiscal year, viz: One hydraulic grader, twenty-eight 100-foot barges, and the steam-launch *Melusina*, which latter boat, in addition to a new steel bottom, had her woodwork entirely renewed and her hand capstan replaced by a steam capstan. Two steam windlasses and five steam pumps were also repaired.

The following plant was transferred during the summer to the other divisions, viz: One mattress boat, one large quarter-boat, two 64-foot barges, and nine 100-foot barges to Omaha Division, and five 100-foot barges to St. Joseph Division. The expenditures on account of repairs to plant, after June 30, 1889, amounted to $30,512.33, which, with the amount expended during the fiscal year ending June 30, 1889, makes the total cost of repairs $102,028.01.

IMPROVEMENT WORKS NEAR LEAVENWORTH, KANSAS.

REVETMENT OF BEE CREEK BEND.

By authority contained in your letter of July 9, the work of protecting the upper part of Bee Creek Bend was begun July 11. On plate I, accompanying this report, are marked the shore lines of Bee Creek Bend for the years 1869, 1879, 1882, 1884, and

1889, also the shore lines in Weston Bend and in Kickapoo Island Chute for the years 1879 and 1889. The following table contains the extent of bank erosion at these localities for the several periods included:

Period of erosion.	Bee Creek Bend.			Weston Bend.*			Kickapoo Island Chute.†		
	Extent of erosion.	Area of erosion.	Estimated erosion.‡	Extent of erosion.	Area.	Estimated erosion.‡	Extent of erosion.	Area.	Estimated erosion.‡
	Feet.	*Acres.*	*Cubic yds.*	*Feet.*	*Acres.*	*Cubic yds.*	*Feet.*	*Acres.*	*Cubic yds.*
1869 to 1879	11,000×401	101.3	5,722,176	.....	.....	.....	.....	.....	.....
1879 to 1882	11,250×401	103.7	5,855,695	10,000× 838.7	192.5	10,872,750	.....	.....	.....
1882 to 1884	10,500×295	71.7	6,016.574	.....	.....	.....	.....	.....	.....
1884 to 1889	13,000×274	81.7	4,614.815	10,600×1,253.9	305.1	16,858,962	17,000×660	319.4	18,033,944
Total..	.....	357.8	20,209.260	.....	497.7	28,102,083	.....	319.4	18,033,944

*Not surveyed in 1869 and 1884; surveyed in 1879, 1882, and 1889.
†Surveyed in 1879 and in 1889, but not in 1882 and 1884.
‡In estimating the prism of erosion the average height of bank eroded is taken at 15 feet, and the depth of scour at 20 feet.

In 1879 protection work of an experimental character was constructed near the middle of the bend. As no further appropriation was made for this improvement until the last river and harbor bill, it was never completed by extending it up-stream, and it was, in consequence, flanked and destroyed by the erosion of the adjacent bank above.

In 1884 the Chicago, Rock Island and Pacific Railway Company constructed the rock-spur dikes marked on Plates I, J, K, L, M, N, for protecting the east approach of their railroad to the Fort Leavenworth Bridge against the encroachment of the river.

The system of revetment adopted as a standard on this division, and which has been fully described in former reports, was employed for the Bee Creek revetment. The mattress has a width of about 86 feet, and extends up the bank to about 7 feet above standard low water

The bank, which was given a slope of from 1 on 2½ to 1 on 2¾, was covered with stone ballast between standard low water and 1 foot above standard high water.

The revetment is divided into two sections by Bee Creek, the upper section beginning 3,250 feet above, and the lower ending 3,408 feet below its mouth at the spur-dike marked J (see Plate I). The revetment is carried up both sides of the creek for a distance of about 100 feet. The construction of revetment above the creek presented no unusual difficulties, the outline of the bank being even. The bank-line below the creek, however, is very irregular, a bench or foreshore from 50 to 100 feet wide, at an elevation slightly above standard low water, extending down-stream several hundred feet below the mouth of the creek. There were also several deep indentations in the bank between the creek and Dike J, caused by eddy action during high stages of water. In two of these indentations, aggregating 440 feet long, the upper bank had been cut back about 50 feet. The bench above described was covered by the mattress, although at the time it was constructed the depth of water on the bench was barely sufficient to float the mattress-boat. Lines of piling were driven across the two larger indentations from point to point, and the piles screened with a wattling of heavy brush, to cause a deposit of fluvial material to form behind them and fair up the bank-line.

About three-fourths of the length of the bank was graded by means of hydraulic grader No. 6; the grading of the rest of the bank, being very light, was carried on by shovels. At the confluence of the creek with the river it was necessary to remove a narrow strip of land about 100 feet long which projected into the river, in order to give an easy bend to the mattress in carrying it up the creek. This was accomplished in the following manner: The soil above water was first washed away by the grader; the soil below water was then loosened by exploding charges of dynamite placed in holes 5 to 10 feet deep made by a water jet; the tow-boat *Wm. Stone* was then run into the creek, and made fast with her paddle-wheel as close to the strip as possible; the wheel being revolved, the earth was washed away to a depth of 3 feet in about three hours.

Two parties were employed constructing mattress; the first began July 18, the second August 15; the mattress was completed September 7. The average area woven per hour, per man, for all labor employed on mattress, amounted to 21 square feet. After September 15, a small force was employed to lay the stone ballast on the upper

bank, the steam launch *Doris* being used for towing the stone-barges on which that material was received.

The revetment was completed November 19, when the barges and quarter-boats were brought to Quindaro boat-yard by the *Doris*. The brush for this work was procured by hired labor. It was cut principally in the vicinity of Weston, Mo., from land where brush had been cut by our parties in 1885. The average cost of brush procured, exclusive of tow-boat service and administration, amounted to $1.762414 per cord. The stone was purchased in open market, 5,234.22 cubic yards being delivered on the river bank at the work at 78½ cents per yard, and 6,939.22 cubic yards on barges at the work at 73½ cents per yard.

The following statement contains the details of the extent and cost of Bee Creek revetment:

Table showing details and cost of 6,658 *linear feet of revetment at Bee Creek Bend.*

Kind of materials and class of work.	Application.	Extent of work.	Total cost.	Cost per linear foot of revetment.
Materials.				
Willow brush	Weaving mattress	573,528 sq. ft.	$6,785.30	$1.019118
Do	Wattling piles	3,600 sq. ft.	86.54	.012098
Do	Filling at toe of bank		119.84	.018001
Stone	Sinking mattress	438,150 sq. ft.	2,154.03	.188349
Do	Covering bank above low water.	278,466 sq. ft.	8,332.04	1.251433
Piles	Anchoring mattress at water line.		1,015.10	.152463
Do	Screen fence		40.47	.006078
⅞-inch wire cable	Re-enforcing mattress and anchoring it to top of bank.	573,528 sq. ft	1,541.83	.231576
¾-inch w re cable			369.67	.055523
Iron stirrup-bolts	Wire cable fastenings		278.00	.041754
Cost of materials			19,822.82	2.977293
Labor and subsistence.				
Weaving and anchoring mattress.	Protecting bank below water line.	573,528 sq. ft.	5,112.01	.767799
Wattling piles	Fairing up bank line	3,600 sq. ft.	119.71	.017980
Filling at toe of bank			10.00	.001502
Sinking mattress		438,150 sq. ft.	354.45	.053237
Covering bank above water-line with stone.	Protecting bank above water line.	278,466 sq. ft.	3,684.00	.553319
Sinking piles	Anchoring mattress at water line.	606 piles	610.78	.091736
Hydraulic grading	Sloping bank to angle of from 1 on 2¼ to 1 on 2¾.	13,535 cu. yds.	625.61	.093964
Grading by shovel		1,571 cu. yds.	140.37	.021083
Cost of labor and subsistence.			10,656.93	1.600620
Miscellaneous.				
Tow-boat service	Transportation of materials and plant.		3,236.53	.486111
Dispatch-boat service	do		2,468.63	.370777
Incidentals	Care of plant, traveling expenses, etc.		1,961.40	.294593
Administration	Superintendence and office work.		937.71	.140840
Cost of miscellaneous			8,604.27	1.292321
Total cost			39,084.02	5 870234

Table showing details and cost, etc.—Continued.

Kind of material and class of work.	Quantities of materials used.	Cost of materials per unit of measure.	Quantities of materials used per 100 square feet of work.	Cost per 100 square feet of work.
Materials.				
Willow brush	3,850 cords	$1.762414	0.67128 cord	$1.18308
Do	50 cords	1.730733	1.38889 cords	2.40389
Do	68 cords	1.762414		
Stone	1,582,69 cubic yards	.792339	0.36122 cubic yard	.28621
Do	10,515.75 cubic yards	.792339	3.77631 cubic yards	2.99212
Piles	606 piles	1.675083		
Do	25 piles	1.618800		
⅝-inch wire cable	38,935 pounds	.039600	6.78868 pounds	.26883
¾-inch wire cable	10,562 pounds	.035000	1.84158 pounds	.06445
Iron stirrup-bolts	2,750	.101091		.04847
Labor and subsistence.				
Weaving and anchoring mattress				.89133
Wattling piles				3.32528
Sinking mattress				.08089
Covering bank above water-line with stone.				1.32296
Sinking piles		1.007888		
Hydraulic grading		.046222		
Grading by shovel		.089351		

IMPROVEMENT WORKS NEAR ARROW ROCK, MISSOURI.

REVETMENT OF NIGGER BEND.

The work of improving the Missouri River in the vicinity of Arrow Rock, Mo., was assigned by you to my charge in February, 1889. This work could not be begun until the following fall, as up to that time all the serviceable plant available was required for carrying on the works in the vicinities of Kansas City, Mo., and Leavenworth, Kans.

A comparison of the-shore lines of the first bend in the river above Arrow Rock, Mo., known as Nigger Bend, as determined by the surveys of 1879 and 1889, showed extensive bank erosion to have occurred during that period. In consequence of this erosion a sand-bar formed at the town, in front of the steam-boat landing, and, as the cutting progressed, has gradually enlarged by extending down stream.

The river bank in the upper part of the bend is higher than the average Missouri River banks, and during rainy weather has a tendency to break off and slide. The bottom lands between the river bank and the bluffs have been, until lately, a lake.

From an inspection of the river on August 15, 1889, it appeared that the cutting in the upper part of the bend was light, the severe cutting being confined to the lower part of the bend, extending from its lowest point 1 mile up-stream.

The length of bank requiring protection was 11,500 feet; the amount appropriated was sufficient to protect only about 4,000 feet, and, as the work had to be begun far enough up the bend to make it safe against flanking, it was possible, with the funds available, to protect only the upper third of the bend.

By your letter of August 24 I was authorized to proceed with this work. The plant for carrying on the work was transferred from Bee Creek Bend, above Fort Leavenworth, in September, by the tow-boat *William Stone*. As the stage of water was then very low and the channel narrow the size of the tows was necessarily small, and considerable time was consumed in towing. It therefore became necessary to reduce the amount of plant to be taken to the work to a minimum of twelve pieces.

Operations were begun September 23 near the head of the bend, about 1 mile below Lisbon, Mo., where, it was believed, the work would be safe from flanking by the erosion of the adjacent bank above. The protection work consisted of the standard type of revetment. The average width of mattress was 95 feet, 75 feet of which was below the water-line. The mattress was completed November 6 and the grading November 7; the ballasting of the graded bank, however, was not finished until December 19, on account of the party who was to furnish the stone failing to supply this material as rapidly as required. For the same feason the ballasting of the upper

ank for the lower 480 feet of the revetment could not be carried as high up the bank by 5 feet as on the remainder of the work.

The average area of mattress woven per hour per man, exclusive of superintendence, etc., for the whole work, amounted to 23.1 square feet. The brush and piling for the work were procured by hired labor. All of the piles and about two-thirds of the brush were obtained about 18 miles above, and the remainder of the brush about 10 miles below the work.

The stone was purchased in the open market, and was delivered at the work, on the river bank, at 69½ cents, and on barges at 67 cents per cubic yard.

The following statement shows the extent of the work and its cost:

Statement of details and cost of 3,935 linear feel of revetment at Nigger Bend.

Kind of materials or class of work.	Application.	Extent of work.	Total cost.	Cost per linear foot of revetment.
Materials.				
Willow brush	Weaving mattress	372,307 square feet	$4,950.76	$1.258134
Do	Filling at toe of bank		51.92	.013194
Stone	Sinking mattress	303,640 square feet	1,024.16	.260269
Do	Covering bank above low-water line.	180,672 square feet	4,500.81	1.143789
Cottonwood piles	Anchoring mattress at water-line.	455 piles	495.36	.125886
⅝-inch wire cable	Re-enforcing mattress and anchoring it at top of bank.	372,307 square feet	947.35	.240750
¾-inch wire cables			150.00	.038247
Iron stirrup-bolts	Wire cable fastenings		399.00	.101398
Cost of materials			12,519.86	3.181667
Labor and subsistence.				
Weaving and anchoring mattress	Protecting bank below water-line.	372,307 square feet	3,310.71	.841349
Covering bank above water-line with stone.	Protecting bank above water-line	180,672 square feet	1,592.63	.404735
Sinking mattress		303,640 square feet	285.35	.065654
Sinking piles	Anchoring mattress at water-line.	455 piles	531.58	.135090
Hydraulic grading	Sloping bank to angle of from 1 on 2¼ to 1 on 2½.	5,853 cubic yards	381.54	.096961
Grading by shovel	....do	1,254 cubic yards	271.48	.068991
Cost of labor and subsistence.			6,346.29	1.612780
Miscellaneous.				
Tow-boat service	Transportation of materials and plant.		7,679.61	1.951616
Incidentals	Care of plant, traveling expenses, etc.		1,744.28	.443273
Administration	Superintendence and office work.		551.63	.140186
Cost of miscellaneous			9,975.52	2.535075
Total cost			28,841.67	7.329522

Table of details and cost, etc.—Continued.

Kind of materials or class of work.	Quantities of materials used.	Cost of materials per unit of measure.	Quantities of materials used per 100 square feet of work.	Cost per 100 square feet of work.
Materials.				
Willow brush	2,860.5 cords	$1.730733	0.76832 cords	$1.32975
Do	30.0 cords	1.730733		
Stone	1,415.8 cubic yards	.723381	0.46628 cubic yards	.33729
Do	6,221.9 cubic yards	.723381	3.44375 cubic yards	2.49115
Cottonwood piles	455 piles	1.088703		
⅝-inch wire cable	23,923 pounds	.039600	6.42561 pounds	.25445
½-inch wire cable	4,300 pounds	.035000	1.15496 pounds	.04042
Iron stirrup bolts	3,940 bolts	.101269	1.05827 bolts	.10717
Labor and subsistence.				
Weaving and anchoring mattress.				.88924
Covering bank above waterline with stone.				.88150
Sinking mattress				.08508
Sinking piles		1.168308		
Hydraulic grading		.065187		
Grading by shovel		.216491		

It is evident that if the work already done is to be of any great benefit, it will be necessary to extend the revetment down-stream to the lower end of the bend, a distance of 7,500 feet.

The estimated cost of this extension is $60,000. If there is any delay in proceeding with the work to completion, considerable erosion of the unprotected portion of the bank will occur, in event of which several dikes will be required on the left bank immediately below the lower end of the bend, to cut away the bar in front of Arrow Rock and restore the steam-boat landing.

The estimated cost of these dikes is $15,000.

IMPROVEMENT WORKS NEAR KANSAS CITY, MISSOURI.

KAW POINT REVETMENT.

During the last two years the river bank in the lower part of Kaw bend has been gradually cutting away. This cutting was caused by a change in the position of the crossing immediately above, by which the bank was exposed to the direct impact of the current.

It has been apparent for some time that, if the erosion continued, changes would occur in the channel of the river between the lower part of the bend and the Hannibal and St. Joseph Railroad Bridge, which would make it dangerous and difficult for steam-boats to pass through the draw-span opening.

A project for revetting the bank from A to C (see Plate III) being approved, construction materials were gotten out during the winter of 1889–'90.

Preparations for carrying on work were completed and the moving of plant from Quindaro boat-yard to Kaw Point by the tow-boat *William Stone* was begun April 5, when a delay of several days in starting the work was caused by an accident to Quarter-boat No. 3, which boat struck an obstruction, while in tow of the *Stone* from the boat-yard to Kaw Point, and had several bottom plank torn off. The boat was saved by being run ashore in about 3 feet of water, and, after two days' work, was raised, taken back to Quindaro, and repaired. Work was begun April 10. The revetment is of the standard type; its length is 1,918 feet. As the bank is composed of very fine sand, it was eroded rapidly when exposed to strong currents or to wave-action. It was, therefore, proposed to grade it to a flatter slope than usual, and, as an extra precaution, to extend the woven mattress up the bank to an elevation of about 11 feet above standard low water.

It was found, however, as the work progressed, that the funds available were insufficient to construct the upper mattress along the entire length of the bank, and only 1,298 feet of bank, beginning 330 feet below the head of the revetment, was protected in this manner. The 330 feet of bank at the head of the work was covered with a loose shingling of brush, while the remaining 290 feet at the lower end was covered with stone ballast, without any other protection.

The width of mattress below the water line, from A to B, a distance of 1,605 feet, varies from 75 to 80 feet; from B to C, a distance of 313 feet, where the current is not very swift and where the erosion resulted principally from wave-action, the mat was narrowed to 40 feet.

The sinking of revetment piles was begun April 10 and completed April 15; mattress-weaving was begun April 12 and completed May 16.

Hydraulic Grader No. 3 was used in grading the bank. This grader is equipped with a Gordon and Maxwell duplex pump with fly-wheels. The water cylinders of the pump are 10 by 12 inches.

The grading could not be carried on continuously on account of the numerous stumps and roots found buried in the bank, which had to be removed, as met with, before the work could proceed.

The following data are compiled from the daily records of grading:

Number of days on which grading was done		13
Total time worked by pump	hours	55.28
Total quantity of material removed in grading	cubic yards	13,377
Average quantity of material removed per hour	do	241.9
Average water-pressure at pump	pounds	138.3
Total travel of pistons per minute	feet	76.4
Coal burned during the 13 days' grading	bushels	345
Length of discharge-hose (4-inch)	feet	75
Length of play-pipe	do	3.62

Nozzle, square ring, 1⅛ inch diameter.

The total cost of grading, including trimming bank with shovels, amounted to about 2½ cents per cubic yard.

The revetment was completed May 28, when the plant was moved to Quindaro boat-yard by the *Melusina* and laid up. All the construction materials were transported to the work on barges by the *Melusina*; this boat also moved all the plant required, excepting a few pieces, which were taken to the work, when it was begun, by the *Wm. Stone*. The extent and cost of Kaw Point revetment are as follows:

Statement of details and cost of 1,918 *linear feet of revetment at Kaw Point.*

Kind of material or class of work.	Application.	Extent of work.	Total cost.
Materials.			
Willow brush	Weaving low-water mattress	137,738 square feet	$2,163.11
Do	Weaving bank mattress	32,606 square feet	292.32
Do	Bank shingling	7,920 square feet	54.34
Stone	Sinking mattress	137,738 square feet	950.77
Do	Ballasting bank above water	68,331 square feet	3,138.44
Cottonwood piles	Anchoring mattress at water-line.		355.08
⅝-inch wire cable	Re-enforcing mattress	137,738 square feet	482.91
¾-inch wire cable	do	137,738 square feet	102.83
Iron stirrup-bolts	Wire cable fastenings		17.72
Cost of materials			7,557.52
Labor and subsistence.			
Weaving and anchoring mattress.	Protecting bank below water	137,738 square feet	1,267.44
Weaving bank mattress	Protecting bank above water	32,606 square feet	248.56
Shingling	do	7,920 square feet	7.00
Sinking mattress		137,738 square feet	124.09
Ballasting upper bank	Protecting bank above water	68,331 square feet	776.57
Sinking piles	Anchoring mattress	165 square feet	186.77
Grading and trimming bank	Sloping bank above water	13,377 cubic yards	284.54
Cost of labor and subsistence			2,894.97
Miscellaneons.			
Service of tow-boat *Wm. Stone*	Transportation of materials and plant.		195.09
Service of tow-boat *Melusina*	Transportation of materials and plant.		1,039.51
Incidentals	Care of plant, etc		341.87
Administration	Superintendence and office work.		386.54
Cost of transportation, etc			1,963.01
Total cost			12,415.50

Table of details and cost, etc.—Continued.

Kind of material or class of work.	Quantities of material used.	Cost of materials per unit of measure.	Quantities of material used per 100 square feet of work.	Cost per 100 square feet of work.
Materials.				
Willow brush	1,015.02 cords	$2.131104	0.736921 cords	$1.570452
Do	137.17 cords	2.131104	0.420689 cords	.896522
Do	25 50 cords	2.131104	0.321970 cords	.686111
Stone	720.4 cubic yards	1.319783	0.523022 cubic yards	.690274
Do	2,378 cubic yards	1.319783	3.480119 cubic yards	4.592966
Cottonwood piles	165 piles	2.152000		
⅜-inch wire cable	9,989 pounds	0.048340	7.252174 pounds	.350600
¾-inch wire cable	2,938 pounds	0.035000	2.133035 pounds	.074656
Iron stirrup-bolts	176	0.106817		
Labor and subsistence.				
Weaving and anchoring mattress				.920182
Weaving bank mattress				762313
Shingling				.088384
Sinking mattress				.090091
Ballasting upper bank				1.136483
Sinking piles		1.131939		
Grading and trimming bank		.021271		

The cost per linear foot of revetment for each class of labor and material is not given in the table, as the character of the bank protection, the width of mattress, and other details vary for different parts of the revetment.

HARLEM AND KANSAS CITY DIKES.

Shortly after work on the Harlem dikes was suspended, the bank at the shore end of dike VIII was cut away for a distance of 30 feet by a strong current flowing through dike VII.

As it was probable that the gap between the end of the dike and the bank would enlarge when the river attained a high stage, the bank was protected for a distance of 70 feet above the gap, and the gap closed by a woven mattress, 50 feet wide, extending out on the dike a distance of 30 feet.

After the river attained a low stage last fall, the dikes constructed at Kansas City and below Harlem in the summer of 1889 were found to have sustained but slight damage.

A few piles were broken off or washed out at the outer ends of the Harlem dikes; none of the braces, however, were broken or displaced, although a great deal of heavy drift-wood lodged in front and on top of the dikes.

The outer ends of the Harlem dikes settled from 1 to 3 feet on account of scour, but there did not appear to be any settling of the Kansas City dikes.

The screen work was damaged to some extent, but not more so than could have been expected, as the types of screens used were experimental; and, at the time it was being constructed, on account of the dikes being nearly submerged, the work could not be done in an entirely satisfactory manner.

Advantage was taken of the low stage of water in the fall of 1889 to repair and complete the screen-work; the shore ends of the Kansas City dikes were also extended back to higher ground to prevent the possibility of their being flanked.

The winter of 1889 and 1890 being mild, no heavy ice was formed, so that the strain on the dikes from the impact of running ice was less severe than that to which they may sometimes be subjected.

Dikes V and VI were not extended last year as far as proposed in the original project, on account of reaching the main channel of the river, which it was considered inadvisable to cross at that time. Notwithstanding that the dikes were incomplete the results that have been attained are very satisfactory, as there has not been at any time since their construction less than 8 feet of water on the crossing into East Bottoms, whereas for several years prior to their construction there was only 3 feet on this crossing. The changes in the cross-sections of the river produced by the dikes in their proximity are shown on Plate IV. Although the stage of water has been uniformly low since the dikes were constructed, and there was no flood last summer nor this spring, the resulting accretions are very extensive and heavy, the depth in some places being 14 feet.

It was proposed as a part of the past spring's operations to complete Dikes V, VI, and VII, by extending them, and to protect the outer or stream end of each of the Harlem dikes against scour, by means of a woven willow apron.

Dikes V and VI were extended as proposed, the former 88 feet, the latter 250 feet. On account of the swift current and deep water at Dike VII, it was considered advisable to postpone its extension until the effect of extending the other dikes above it would lessen these difficulties and make it possible to do the work more effectually and economically.

The extensions are of the same design as the dikes constructed last year, described in the Annual Report for 1889. They were placed on the up-stream sides of the older structures, and, to insure a perfect connection with the latter, were lapped over them back of where any settling had occurred. This lap amounted to 40 feet at Dike V, and to 16 feet at Dike VI.

The aprons consist of woven mattress, made of medium-size smooth brush, reenforced by four longitudinal $\frac{5}{8}$-inch cables. It is attached to the piles of the middle line of the dike by means of $\frac{5}{8}$-inch cables, which are secured to the longitudinal cables of the apron at every bent of piles, or 8 feet apart. The inner edge of the apron is also woven around a $\frac{3}{4}$-inch cable stretched along the water-line and fastened to each of the piles on the upper line of the dike.

The aprons were begun at the edge of the accretions and carried along the up-stream line of piling to the stream ends of the dikes, around which they were extended and secured to the lower line of piling by means of the longitudinal cables. The apron at Dike V varied from 30 to 37 feet wide, at Dike VI the width is 32 feet, and at Dike VIII 41 feet.

As the aprons were liable to be rolled up by the current at Dikes V and VI, if left afloat during construction, they were supported by cables, 16 feet apart, attached at the outer edge, the other ends of the cables being made fast to a 100-foot barge held about 60 feet above the dikes by mooring-piles.

A sufficient quantity of stone was wired to the mattress to cause it to sink quickly when the suspension cables were cut, after which other stone was thrown on the apron at random.

From the experience had so far in dike construction it appears that the system of bracing employed is sufficiently strong; the piles, however, should be sunk with the point instead of the butt-ends down as has been the practice. At the outer five or six bents heavy oak piles 45 to 50 feet long should be used, which, being sunk as deep as possible by the jet, should be driven with the hammer to a penetration of not less than 25 feet. The standard pile-sinkers are not adapted to sinking piles over 30 feet, point down, and if this change of detail in dike work is adopted the present arrangement of derrick and platform on the cross-boat will have to be replaced by a set of leads.

As each class of work was of no great extent, and as inexperienced men had to be employed in its construction, the work was more expensive than if it had been carried on on a larger scale by a well-trained party.

Amount expended on the Harlem and Kansas City dikes to the end of the last fiscal year	$26,918.80
Amounts expended since June 30, 1889:	
Securing shore end of Dike VIII	345.18
Extending shore ends of Dikes I and II	413.04
Extending and repairing screen-work at Dikes I, II, V, VI, VII, and VIII	649.08
Extending Dikes V and VI	3,875.79
Constructing aprons at V, VI, and VIII	1,470.70
Total amount expended on Harlem and Kansas City dikes to June 30, 1890	33,672.59

For the purpose of contracting the river to the proper width, Dikes I, II, and VII, will have to be extended about 130, 100, and 100 feet, respectively; the outer ends of these dikes will also have to be protected against scour by aprons; the estimated cost of which work is $4,000.

If the river is to be held on the lines adopted and the full effect accomplished by the dikes maintained, it will be necessary to prevent any further cutting of the bank above Dike V by protecting it by revetment for a distance of about a half mile. If this cutting is not checked the dikes will ultimately be flanked.

The estimated cost of the revetment is $20,000.

REPAIRS TO KAW BEND REVETMENT.

During the summer of 1889, about 200 feet of the toe of the bank at the lower end of upper Kaw Bend settled slightly. To prevent further injury to the work, it was

thought advisable to grade the bank to a flatter slope and renew the upper bank protection. This work was done during the fall of 1889. The stone ballast, above water, was removed, and a heavy filling of brush placed behind the anchorage piles at the toe of the bank; the bank was then graded and the stone ballast replaced. The cost of this work, including 375 cubic yards of stone, amounted to $1,141.70.

EAST BOTTOMS REVETMENT.

Slight repairs to the East Bottoms revetment were made necessary by the upper bank settling for short distances at two points. This settling was caused by reef-action during the summer of 1888. The repairs consisted in fairing up the shore-line by driving a line of piles across the breaks at the water's edge, and by filling in behind the piles with brush, which was covered with stone ballast.

The total cost of these repairs amounted to $481.31.

DIKES AT LITTLE PLATTE BEND.

As the highest stage attained by the Missouri River above the mouth of the Kansas River last year was several feet lower than below that tributary, the depth of the accretions around the dikes at Little Platte Bend was not as great as at the dikes at Kansas City and Harlem. The indications, however, are that the dikes will eventually accomplish the purpose for which they were intended, viz, to fair up the shore-line in the upper part of the bend. On June 5, just before the present high water, the dikes were in good condition with the following exceptions, viz: Dike I, two outer bends gone; Dike II, seven outer bends gone; Dike III, two outer bends gone.

As all the money available this spring was required for the more important works near Kansas City, the stream ends of these dikes could not be protected by mattress aprons as was done at the Harlem dikes. Unless this work is done in the course of a few years the dikes will be washed away to such an extent as to make extensive repairs necessary.

The changes in cross-section of the river effected last summer by the dikes at Little Platte Bend are shown on Plate N.

IMPROVEMENT WORKS IN THE VICINITY OF MIAMI, MISSOURI.

DIKES AT MIAMI.

From a survey and examination of the Missouri River in the vicinity of Miami, during September, 1889, and from information obtained from other sources, it appears that for several years prior to 1878, the main channel of the river followed the bluffs at the town. Subsequent to 1878, changes occurred in the river above Miami which diverted the channel to the left bank and caused extensive erosion opposite the town. From a comparison of the maps of surveys of 1878 and 1889, it appears that the greatest width of this erosion is about 1,100 feet.

As this cutting proceeded, the impact of the current was gradually transferred along the right bank in the bend below Miami, and several hundred acres of rich farming land, situated principally at the head of the bend, were washed away. During the last two years there has been a slight cutting of the left bank above referred to; a sand bar has formed opposite the head of the bend and a heavy erosion has taken place between the middle and lower end of the bend.

As another result of the cutting of the left bank the river at Miami became excessively wide, causing a middle bar to form which divides the river into two chutes.

According to the survey of September, 1889, the sectional area of the north chute was 36 per cent. of the total area of cross-section. If the left bank cuts back much further the north chute will probably enlarge, and the middle bar join on to the right bank, in event of which the town will lose its steam-boat landing.

A project for the improvement of the Missouri River in the vicinity of Miami, Mo., was submitted under date of November 5, 1889. This project comprised the improvement of the reach between the head of Miller's Island and 1 mile below Miami.

A part of the works proposed in the latter part of the project, with slight modifications, being approved, I was authorized by your letter of November 7, 1889, to procure the necessary materials and to proceed with construction as soon as the ice was out of the river in the spring.

The approved portion of the project consisted of the construction of parts of three dikes marked Z 1, Z 2, Z 3, on Plate VII, aggregating 1,600 linear feet. The stone, piling, and lumber for the work were gotten out last winter, and the brush early this spring. As the river remained open all winter, arrangements were made with a view

to beginning operations early in March, and the tow-boat *William Stone* left the winter harbor at Bushberg, Mo., February 26, to move the plant lying at Bluffport, Mo., and several pieces stored at Kansas City, to Miami.

In the latter part of February the weather suddenly turned very cold and numerous ice gorges formed in the river, in consequence of which the *Stone* had to lay up at Chamois, about 121 miles above the mouth of the river, until after the ice moved out in March.

The plant lying at Bluffport, Mo., reached Miami April 1, and that stored at Kansas City, April 12. The necessary preparations for work being completed, pile sinking on Dike Z 3 was begun April 16.

The stage of water remained so low during the time work was in progress that the sand-bar across which it was proposed to carry Dike Z 3 was several feet above water. In consequence of this, as there was no pile-driver available for driving piles on the bar, only that portion of Z 3 situated between the bank and the bar, could be constructed. The materials intended for the remainder of this dike were, with your approval, used in extending Dikes Z 1 and Z 2, the former being extended 120 feet and the latter 230 feet farther than it had been proposed to carry them this spring.

The dikes are of the same general design as the three-row dikes constructed in the vicinity of Kansas City in 1889, excepting that the piles were sunk point down, and that for three bents at the outer ends of Z 1 and Z 2 six rows of piles were used instead of three rows.

The tops of the dikes at the shore ends are 12 feet and at the stream ends 10 feet above standard low water.

For a distance of about 60 feet at the shore end of Dike Z 1 the thickness of the sand covering the bed-rock was not sufficient to hold the piles; and this part of the dike consisted of a crib, to which piles were attached, the crib being sunk by loading it with stone.

The lengths of the dikes, exclusive of a 25-foot L at the outer end of Z 1 and Z 2, are as follows, viz: Z 1, 308 feet, Z 2, 737 feet, Z 3, 207 feet.

The brush and piling for the work were procured by hired labor; the average cost of these materials, exclusive of the cost of transportation by boat, amounted for the former to $1.57 per cord, and for the latter to $0.037 per linear foot. The stone was purchased in the open market, at a cost of 90 cents per cubic yard, delivered on the river bank about a half-mile above the dikes. The lumber used for bracing dikes and for foot-mat is elm and cottonwood, and cost delivered on the river bank, exclusive of loading on barges and transportation to the work from the point of delivery $10.93 per 1,000 feet, B. M.

The cost of constructing the dikes exceeded their estimated cost, on account of the extraordinary expenses incurred by unavoidable delays in assembling the plant described above.

Work was closed June 4, the dikes being completed, as far as carried, excepting the lashing of wales and braces on Z 1 and the outer end of Z 2.

The greatest number of piles sunk in one day was 30. The average number per diem was 17.

The average penetration of the piles in each of the dikes is as follows: Z 1, 15.1 feet; Z 2, 19.8 feet; Z 3, 19.33 feet.

The shallow penetration at Z 1 is due to encountering bed-rock.

There has been no opportunity, since the dikes were completed, to ascertain their effect during the high water of this month. They are reported by the fleet watchman to be in good condition, with a heavy accumulation of drift-wood against Z 1.

Quantities of materials used and cost of constructing 1,302 *linear feet of* 3*-row dike, including a* 25*-foot L at stream end of Dikes Z* 1 *and Z* 2.

Class of work, quantities of materials, etc.	Prices of materials.	Cost of each class of work.
Sinking 469 *piles.*		
Labor and subsistence	.....	$758.75
795 bushels coal fuel	$0.140542	111.73
3.3 cords wood, fuel	3.000000	9.90
401 pounds 1¼-inch manilla rope, pile lines	0.160000	64.16
Oils, tallow, waste, etc	.....	53.60
67 pounds ⅞-inch round iron for jet-pipe staples	0.028000	1.60
17,264 linear feet piling	0.036999	638.77
Total	.....	1,638.51

Quantities of materials used and cost, etc.—Continued.

Class of work, quantities of materials, etc.	Prices of materials.	Cost of each class of work.
Bracing 1,242 *linear feet of dike.*		
Labor and subsistence		$416.38
612 pieces elm lumber, 4 inches × 6 inches × 15 feet, 18,360 feet, B. M	$11.277300	207.05
156 pieces elm lumber, 4 inches × 6 inches × 22 feet, 6,864 feet, B. M	13.777300	94.57
4,752 feet B. M. assorted elm lumber		58.87
200 pounds 5-inch spikes	0.032500	6.50
800 pounds 8-inch spikes	0.032500	26.00
4,061 pounds ⅝-inch square iron	0.025000	101.53
4,752 linear feet waling	0.036999	175.82
Total		1,086.72
Lashing 907 *linear feet of dike on Z* 1 *and Z* 2.		
Labor and subsistence		90.89
3,200 pounds ⅜-inch wire cable	0.039600	127.72
Total		218.61
Constructing 1,242 *linear feet foot-mat* 30 *feet wide.*		
Labor and subsistence		562.50
1,500 pieces elm lumber, 2 inches × 6 inches × 12 feet, 18,000 feet, B. M	11.277300	202.99
587 pieces elm lumber, 3 inches × 4 inches × 24 feet, 14,088 feet, B. M	13.777300	194.10
482.92 cords brush	1.575497	760.84
1,345 pounds wire, No. 10	0.037049	49.83
186 pounds 5-inch spikes	0.032500	6.05
93 pounds 40-penny nails	0.027500	2.56
Total		1,778.87
Sinking 1,242 *linear feet foot-mat.*		
Labor and subsistence		144.38
480 cubic yards stone	1.247424	598.77
Total		743.15
Connecting dikes with shore.		
Labor and subsistence		98.32
117 pieces elm lumber, 2 inches × 6 inches × 12 feet, 1,404 feet, B. M	11.277300	15.83
46 pieces elm lumber, 3 inches × 4 inches × 24 feet, 1,104 feet, B. M	13.777300	15.21
37.75 cords brush	1.575497	59.47
105 pounds wire, No. 10	0.037049	3.89
14 pounds 5-inch spikes	0.032500	.45
7 pounds 40-penny nails	0.027500	.19
162 cubic yards stone	1.247424	202.08
Total		395.44
Constructing 60 *linear feet crib-work at shore end of Dike Z* 1.		
Labor and subsistence		102.86
180 pieces elm lumber, 2 inches × 6 inches ×12 feet, 2,160 feet, B. M	11.277300	24.36
60 pieces elm lumber, 4 inches × 6 inches × 15 feet, 1,800 feet, B. M	11.277300	20.30
615 linear feet piling	0.036999	22.76
1,000 pounds ⅜-inch steel wire cable	0.039600	39.60
150 cubic yards stone	1.247424	187.11
Total		396.99
Screening 1,335 *linear feet of dike, including* 87 *feet of shore connection.*		
Labor and subsistence		202.42
30 pieces elm lumber. 2 inches × 6 inches × 12 feet, 360 feet, B. M	11.277300	4.06
30 pieces elm lumber, 3 inches × 4 inches × 24 feet, 720 feet, B. M	13.777300	9.92
198.5 cords brush	1.575497	312.74
50 pounds No. 10 wire	.037000	1.85
200 pounds 6-inch spikes	.032500	6.50
Total		537.49
Administration		600.00
Incidental expenses		801.73
Service of steamer *Doris* transporting materials		827.56
Service of steamer *Wm. Stone* moving plant		4,178.93
Aggregate cost		13,204.00
Or $10.14 per foot.		

Cost per foot, exclusive of moving plant, $6.93.

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MISSOURI RIVER COMMISSION.

KANSAS CITY DIVISION

MAP OF MISSOURI RIVER

from

KICKAPOO KANSAS,

to

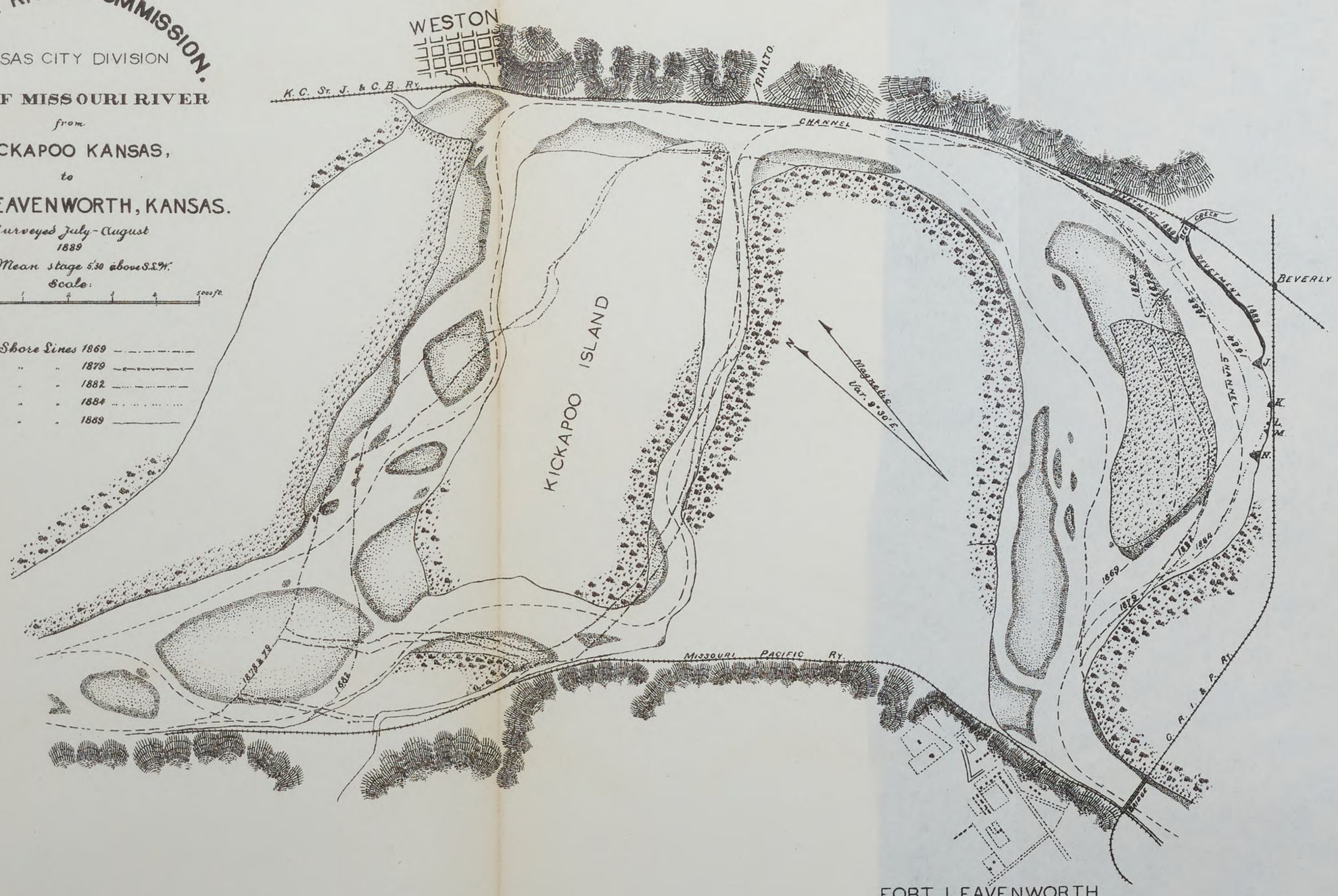
FORT LEAVENWORTH, KANSAS.

Surveyed July - August 1889

Mean stage 5.30 above S.L.W.

Scale: 1" = 2000 ft.

Note
- Shore Lines 1869
- " " 1879
- " " 1882
- " " 1884
- " " 1889



To accompany annual report for 1890 of S. H. Yonge, Division Engineer

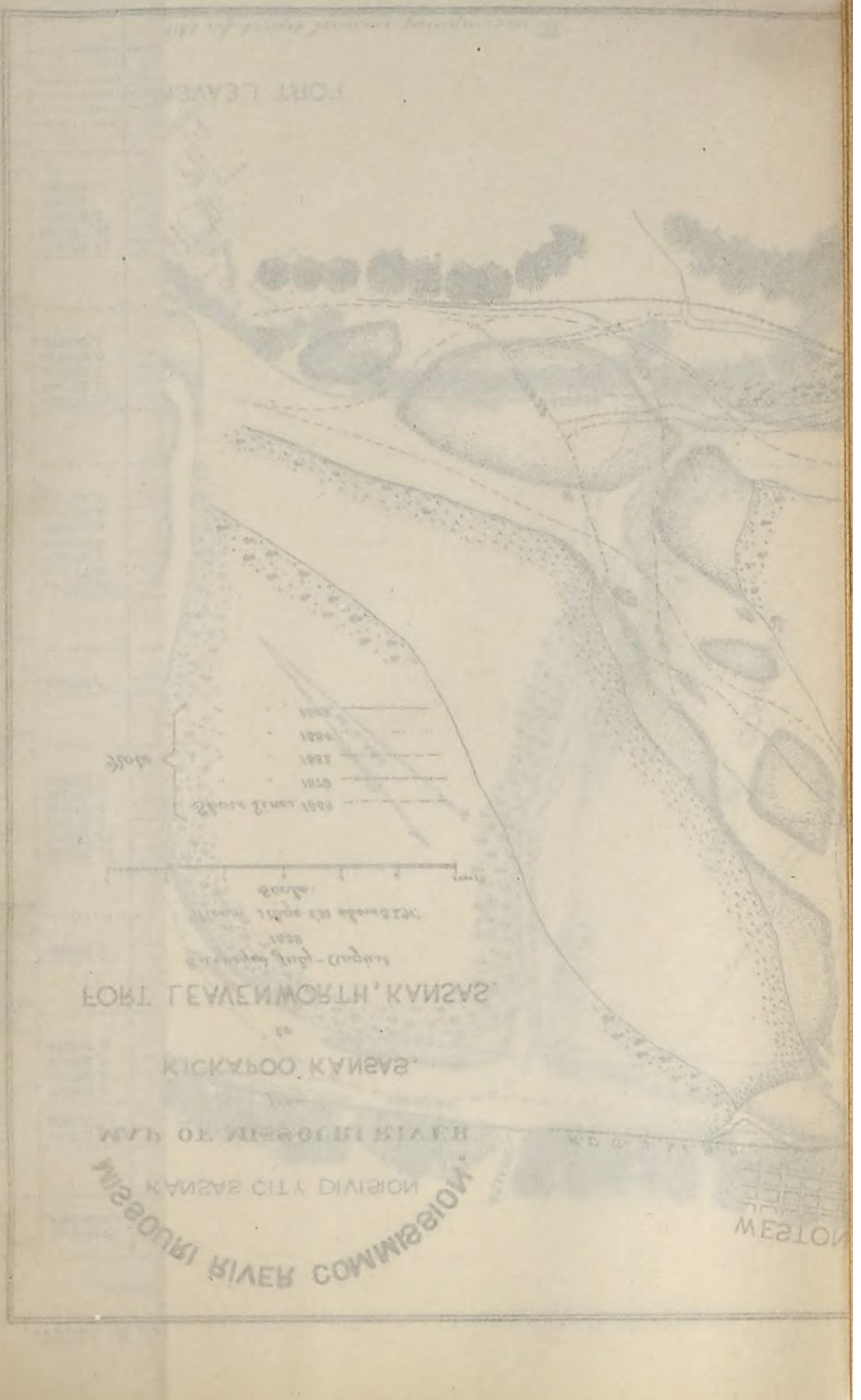


PLATE II

Missouri River Commission,

KANSAS CITY DIVISION.

MAP OF MISSOURI RIVER

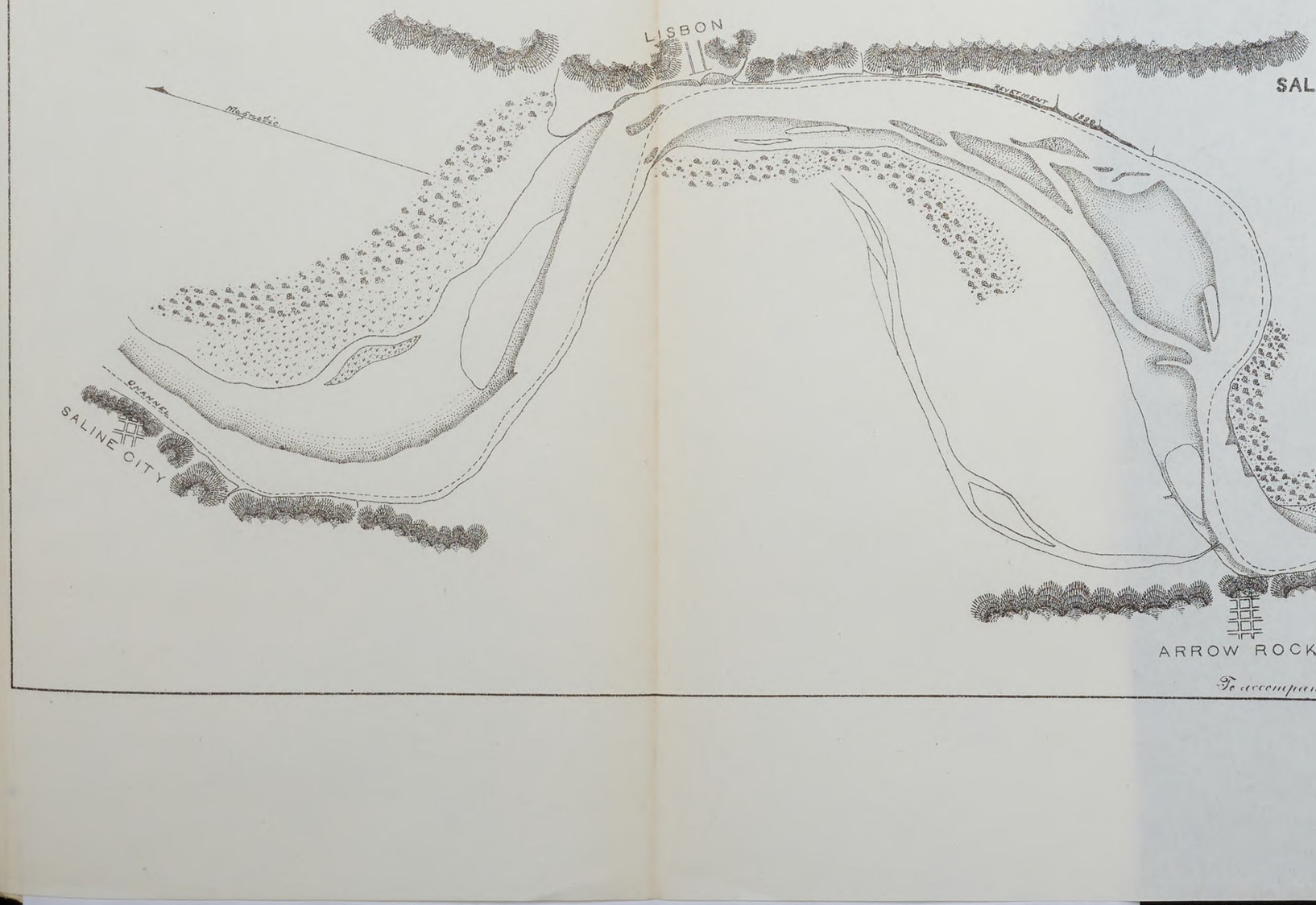
FROM

SALINE CITY, MO., TO ARROW ROCK, MO.

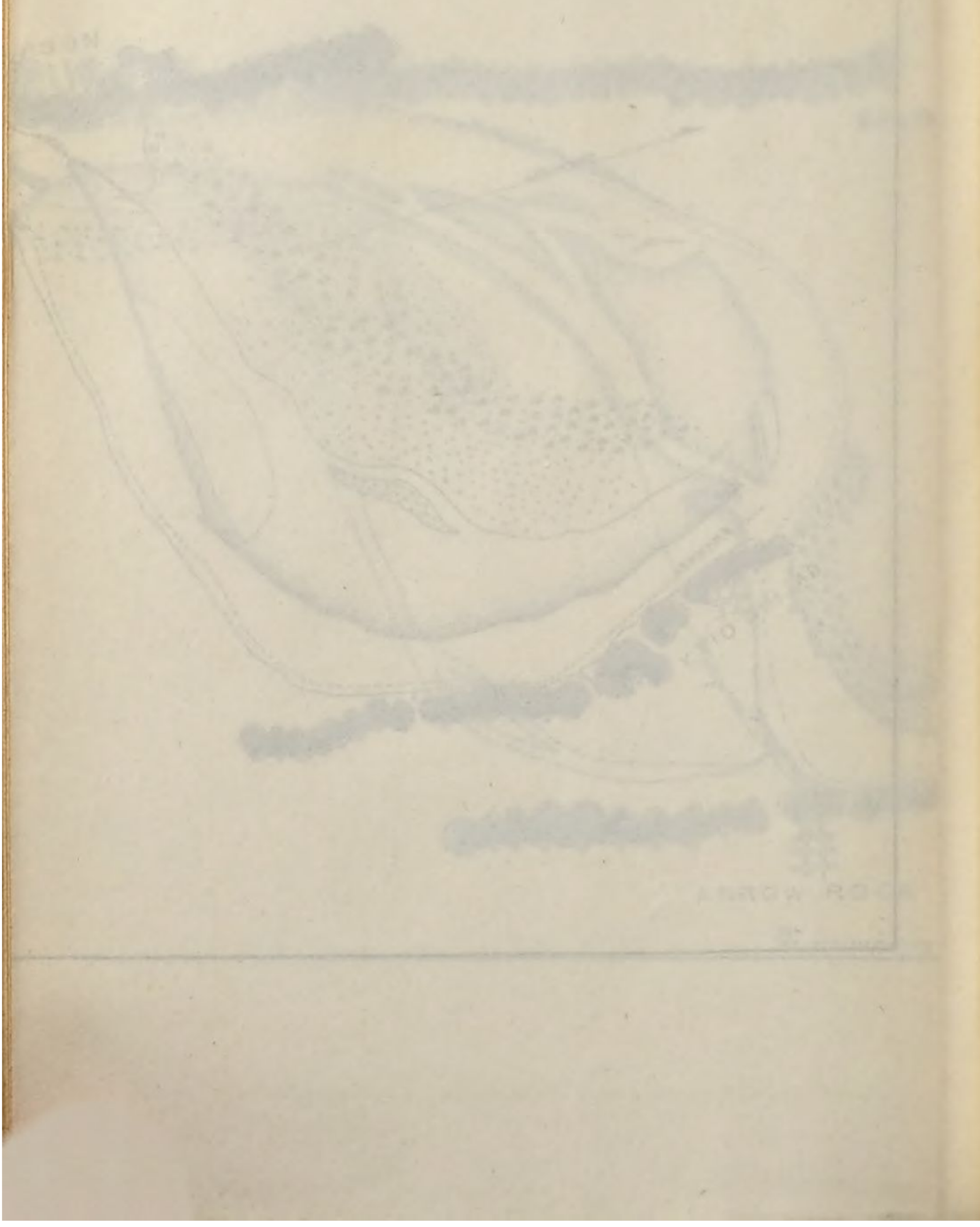
SURVEYED SEPT.-OCT. 1889,

MEAN STAGE, 1 FT. BELOW S.L.W.

SCALE: 1000' 500 0 1000 2000 3000 FEET.



To accompany annual report for 1890 of S. H. Yonge, Division Engineer.



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MISSOURI RIVER COMMISSION

KANSAS CITY DIVISION.

MAP OF MISSOURI RIVER

IN THE VICINITY OF

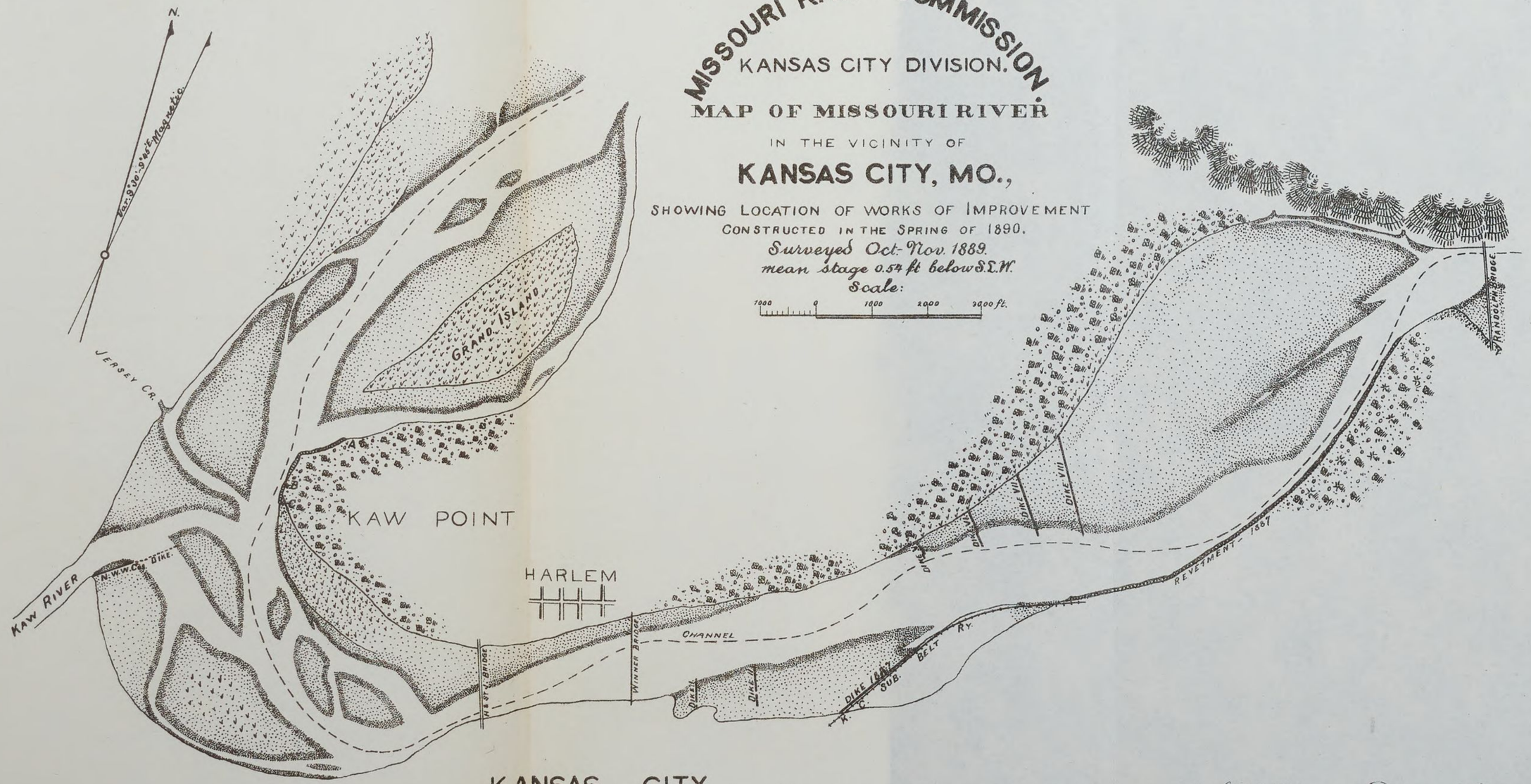
KANSAS CITY, MO.,

SHOWING LOCATION OF WORKS OF IMPROVEMENT
CONSTRUCTED IN THE SPRING OF 1890.

Surveyed Oct-Nov. 1889.
mean stage 0.54 ft below S.L.W.

Scale:

1000 0 1000 2000 3000 ft.


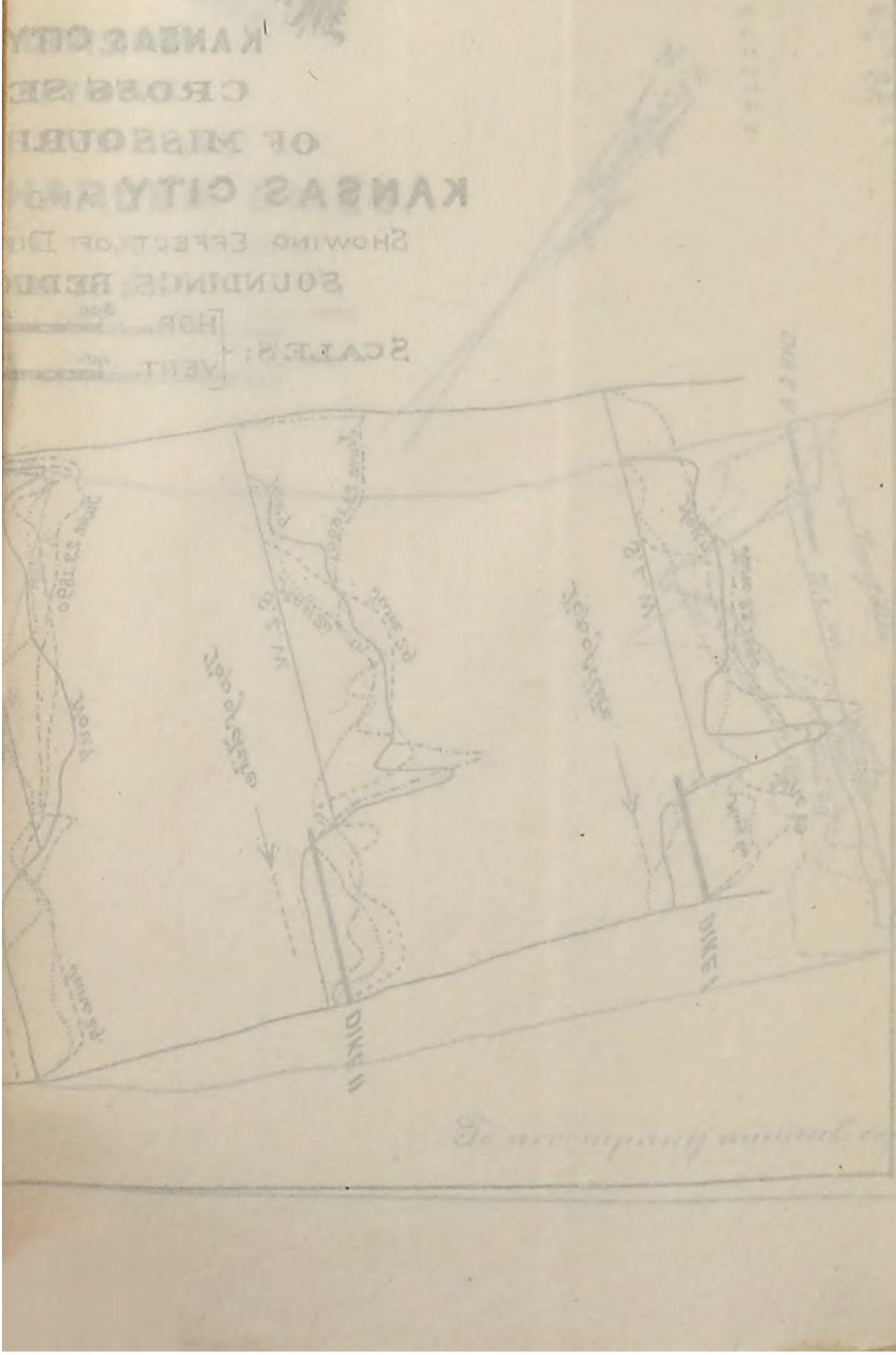
To accompany annual report for 1890 of S. H. Yonge, Division Engineer

MISSOURI RIVER COMMISSION
KANSAS CITY DIVISION
KANSAS CITY, MO.
KAW POINT
KANSAS CITY

43

PLATE IV


Missouri River Commission,
KANSAS CITY DIVISION.
CROSS SECTIONS
OF MISSOURI RIVER AT
KANSAS CITY AND HARLEM DIKES,
SHOWING EFFECT OF DIKES TO JUNE 25, 1890.
SOUNDINGS REDUCED TO S.L.W.
SCALES; HOR. 300 0 300' 600' 800 FEET.
VERT. 10' 0 10 20 30 FEET.
NOTE:
STAGE OF WATER APRIL 25, 1889 = 3.04 FT. ABOVE S.L.W.-K.C.GAUGE.
" " 26, " = 3.04 " " " "
" MAY 20, " = 7.39 " " " "
" JUNE 28, " = 5.88 " " " "
" " 29, " = 5.59 " " " "
" NOV. 7, " = 0.00 " " " "
" JUNE 23, 1890 = 8.04 " " " "
" " 24, " = 9.86 " " " "
" " 25, " = 10.00 " " " "
N
Var. 9°30' to 9°45' E
Magnetic
DIKE I
DIKE II
DIKE V
DIKE VI.
DIKE VII
DIKE VIII
S.L.W.
Top of dike
June 23, 1890
Nov. 7
May 20
June 29
June 24, 1890
April 26
April 25
June 28
June 25, 1890
To accompany annual report for 1890 of S. H. Yonge, Division Engineer.



Missouri River Commission,

KANSAS CITY DIVISION.

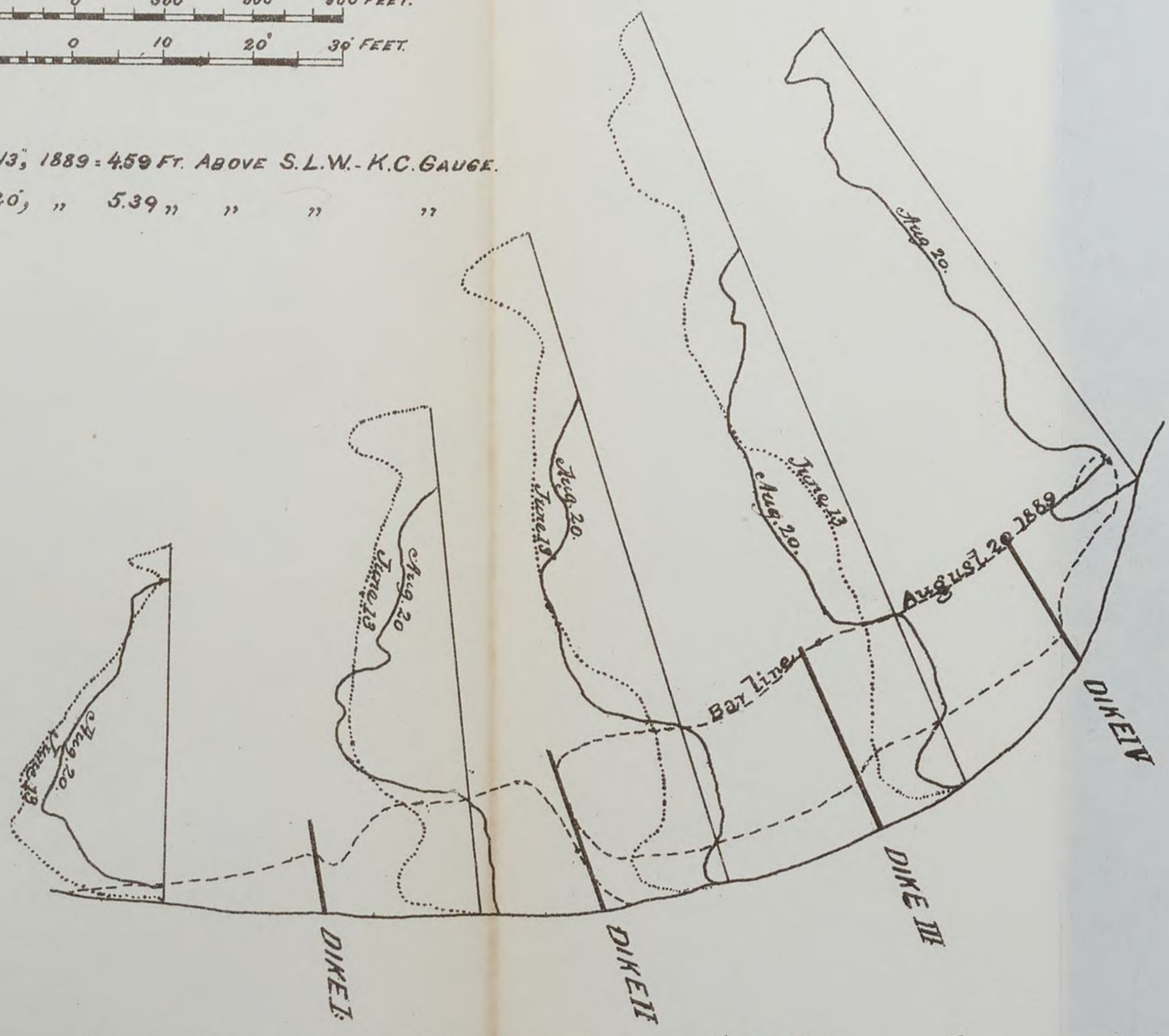
CROSS SECTIONS OF MISSOURI RIVER AT LITTLE PLATTE BEND DIKES,

SHOWING EFFECT OF DIKES TO AUG. 20TH 1889

SCALES: HOR. 300' 0 300' 600' 900' FEET.
VERT. 10' 0 10 20' 30' FEET.

NOTE:-

STAGE OF WATER JUNE 13TH 1889 = 4.59 FT. ABOVE S.L.W.-K.C.GAUGE.
" " " AUG. 20TH " 5.39 " " " "



To accompany annual report for 1890 of S. H. Yonge, Division Engineer.

PLATE VI

MISSOURI RIVER COMMISSION

KANSAS CITY DIVISION.

MAP OF MISSOURI RIVER

in the vicinity of

MIAMI, MO.,

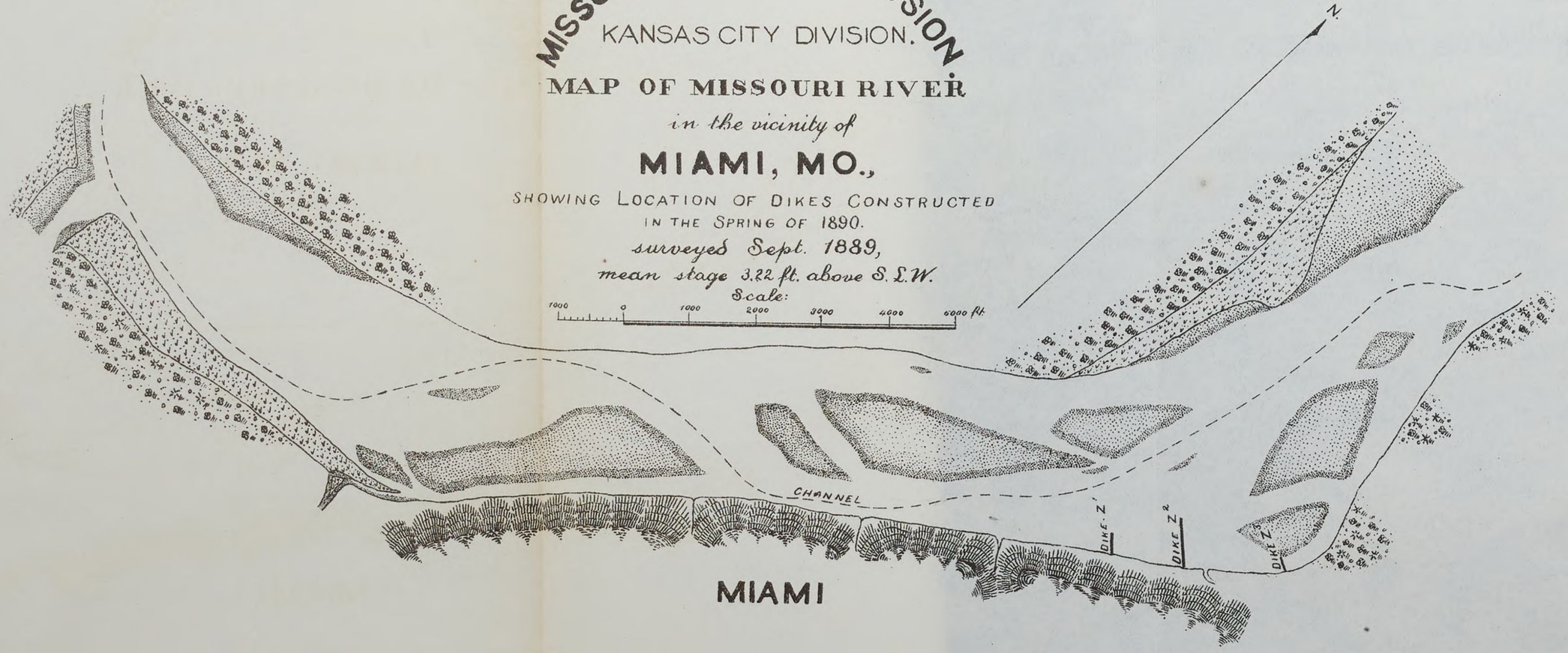
SHOWING LOCATION OF DIKES CONSTRUCTED IN THE SPRING OF 1890.

surveyed Sept. 1889,

mean stage 3.22 ft. above S. L. W.

Scale:

1000 0 1000 2000 3000 4000 5000 ft.



To accompany annual report for 1890 of J. H. Yonge, Division Engineer.

MISSOURI RIVER COMMISSION
KANSAS CITY DIVISION.
MAP OF MISSOURI RIVER
MIAMI
1939
MIAMI

Preserve original export for this

CURRENT REPAIRS AND CARE OF PLANT ON KANSAS CITY DIVISION.

The plant used at Nigger Bend in the fall of 1889 was laid up in a winter harbor, at Bluffport, Mo., until April 1, 1890, when it was taken to Miami, Mo.

After work was closed at the latter place the plant was left there in charge of watchmen. The remainder of the plant belonging to Kansas City division was stored on the ways at Quindaro boat-yard during the winter, and with the exception of fourteen pieces, was launched during the spring for use on the works in the vicinities of Kansas City, Mo., and Miami, Mo.

Since operations were suspended at Kansas City, Mo., the plant used on that work has been taken care of at the boat-yard. Although all the plant was repaired last year, it was found necessary to replace timbers which at the time general repairs were made appeared to be sound.

Before storing the plant last fall at the boat-yard a portion of the ways had been rebuilt on account of deterioration from age.

The total cost of current repairs and care of plant on this division, including repairs to launching-ways, storing and launching boats, rent of ground, watching plant at Quindaro, Arrow Rock, and Miami, raising and repairing quarter-boat No. 3, etc., amounts to $10,993.07.

SURVEYS.

Surveys were made of the Missouri River from the head of Weston Bend to Fort Leavenworth, Kans.; from Saline City, Mo., to Arrow Rock, Mo.; from Quindaro, Kans., to Randolph Bluffs; from the foot of Miller's Island to 1 mile below Miami; also at the cable ferry near Quindaro, Kans.; at the pontoon bridge, Lexington, Mo., the Hannibal and St. Joseph Railroad Bridge at Kansas City, Mo., and the Missouri, Kansas, and Texas Railroad Bridge at Boonville, Mo.; the four latter surveys included current observations of the river at the ferry and bridge crossings.

During the past fiscal year 40 sheets of tracings of maps, pertaining principally to the above surveys, were prepared at this office and forwarded to you.

The Missouri River water-gauges between Fort Leavenworth, Kans., and Lexington, Mo., were kept in repair and inspected monthly up to January, 1890, since which time this duty has been performed for all the gauges between Fort Leavenworth, Kans., and St. Charles, Mo. The cost of surveys amounted to $2,870.01; that of inspecting and repairing water-gauges to $693.07.

I have been assisted in conducting the operations of the past year by Assistant R. H. Bacot, in charge of general repairs to plant, construction of revetment at Kaw Point, and extending the Harlem and Kansas City dikes; by Assistant A. H. Weber, in charge of construction of revetment at Bee Creek and Nigger bends and the dikes at Miami. The special surveys and gauge inspections were made by Mr. R. A. Crawford, who also made most of the maps forwarded from this office. I take pleasure in stating that these gentlemen performed their duties in a creditable manner.

Very respectfully, your obedient servant,

SAML. H. YONGE,
Division Engineer.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

APPENDIX Y Y.

BRIDGING NAVIGABLE WATERS OF THE UNITED STATES.

1. Report of Board of Engineers on Senate bills Nos. 3901 and 3980, Fiftieth Congress, second session, to authorize the construction of bridges across the Mississippi River above and below New Orleans, La.
2. Report of Board of Engineers on H. R. bill No. 10437, Fifty-first Congress, first session, to authorize the construction of a high, level bridge across the Mississippi River at or near the lower limits of the city of New Orleans, La.
3. Report of Board of Engineers respecting the practicability and necessity of a bridge across Detroit River at Detroit, Mich.
4. Report of a Board of Engineers on the practicability and approximate cost of tunneling the Detroit River at or near Detroit, Mich.
5. Report of Board of Engineers on plans and location of proposed bridge across the Ohio River between Louisville, Ky., and Jeffersonville, Ind.
6. Report of Board of Engineers respecting bridges across Charles River, Mass., interfering with navigation.
7. Report of Board of Engineers on alleged obstruction of navigation by certain bridges over Harlem River, New York.

Y Y 1.

REPORT OF BOARD OF ENGINEERS ON SENATE BILLS NOS. 3901 AND 3980, FIFTIETH CONGRESS, SECOND SESSION, TO AUTHORIZE THE CONSTRUCTION OF BRIDGES ACROSS THE MISSISSIPPI RIVER ABOVE AND BELOW NEW ORLEANS, LOUISIANA.

WAR DEPARTMENT,
Washington City, December 14, 1889.

SIR: In reply to the letters from the Committee on Commerce, dated February 7 and June 29, 1889, inclosing Senate bills 3901 and 3890, to authorize the construction of certain bridges across the Mississippi River at New Orleans, La., I have the honor to transmit herewith a letter from the Chief of Engineers, dated the 12th instant, together with a copy of a report from the Board of Engineer officers convened to examine into and report upon the bills referred to, and a copy of the report of the Mississippi River Commission on Senate bill No. 3901.

The conclusions of the Board are concurred in by the Chief of Engineers and by this Department.

Very respectfully,

REDFIELD PROCTOR,
Secretary of War.

Hon. WILLIAM P. FRYE,
Chairman Committee on Commerce,
United States Senate.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 12, 1889.

SIR: The Senate Committee on Commerce, by letter dated February 7, 1889, requested the views of the Secretary of War upon the merits of S. 3901, Fiftieth Congress, second session, "A bill to authorize the construction of a bridge across the Mississippi River at New Orleans, Louisiana," and under date of the 29th of June, 1889, the same committee requested similar information respecting S. 3980, Fiftieth Congress, second session, "A bill to authorize the New Orleans Terminal Railway and Bridge Company to construct, operate, and maintain a bridge, and all the necessary approaches thereto, over the Mississippi River from or near the lower limits of the city of New Orleans, La., on the left bank of the Mississippi River, to the opposite bank in said State."

These bills were referred to the Board of Engineer officers convened by your authority by Special Orders No. 74, headquarters Corps of Engineers, dated November 15, 1889, to consider and report upon the bills referred to, and I have now the honor to submit a copy of the report of the Board, dated November 30, with copies of accompanying papers.

In regard to Senate bill 3901, the Board states that it "provides for a continuous bridge across the Mississippi River above New Orleans and has the general provisions common to most bridge laws. It leaves the entire control of lengths and heights of spans in the hands of the Secretary of War, and, as under its provisions a bridge can be built which will offer no serious obstruction to navigation, the Board sees no objection to its passage.

"Senate bill 3980 provides for a draw-bridge across the Mississippi River near the lower limits of New Orleans. It leaves to a Board of Engineers and to the Secretary of War the power of fixing the length of spans, and the height above water even up to heights which will permit the largest ships to go under it with all their upper masts in position while the draw is closed."

It is evident that no such height was contemplated by the promoters of the bill. It may be noted, however, that sections 3 and 6 are not entirely concordant.

The Board concludes as follows:

> Any bridge is an obstruction. But one bridge is needed (if indeed that one be at present needed) for railroad purposes at New Orleans, and that should be above the city.

The Board has given the subject careful consideration and its conclusions are concurred in by me. I see, therefore, no objection to the passage of Senate bill 3901.

The letters of the Committee on Commerce are herewith returned with copy of report from the Mississippi River Commission upon the first-mentioned bill S. 3901.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

REPORT OF BOARD OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., November 30, 1889.

GENERAL: The Board convened by Special Orders No. 47, Headquarters Corps of Engineers, November 15, 1889, to consider and report on Senate bills Nos. 3901 and 3980, Fiftieth Congress, second session, met in public session after due notice, at New Orleans, on November 29, 1889.

It heard the various interests which appeared before it and has the honor to submit the following report:

Senate bill 3901 provides for a continuous bridge across the Mississippi River, above New Orleans, and has the general provisions common to most bridge laws. It leaves the entire control of lengths and heights of spans in the hands of the Secretary of War, and, as under its provisions a bridge can be built which will offer no serious objection to navigation, the Board sees no objection to its passage.

Senate bill 3980 provides for a draw-bridge across the Mississippi River near the lower limits of New Orleans. It leaves to a Board of Engineers and to the Secretary of War the power of fixing any length of spans and any heights above water, even up to heights which will permit the largest ships to go under it, with all their upper masts in position while the draw is closed. Although it is evident that no such height was contemplated by the promoters of the bill, with such power in the hands of the Secretary of War no objection is seen to the passage of this bill. It may be noted, however, that sections 3 and 6 seem not entirely concordant.

While the bills referred to the Board do not fix the heights or the lengths of spans, the promoters of both bridges have nevertheless presented definite plans fixing such heights and lengths. This makes a consideration of the question involved necessary.

The registered tonnage on the river below New Orleans is estimated at over 2,000,000 tons. That on the river immediately above New Orleans is estimated at over 3,000,000 tons.

Mr. Hutchinson, president of the Morgan Steam-ship Company, estimates the number of cars transferred across the river at New Orleans in 1889 as 220,000. This would be about 600 a day.

This commerce moving on the river and this commerce crossing the river are the two interests chiefly involved, and it is seen that both are large. A bridge across the river would be used in but a relatively small degree for any other interest than that of the railroads. So far as the railroads are concerned the bridge would be used mainly for transferring freight and passengers from the roads on one side of the river to those on the other. A transfer from the principal roads on the right bank of the river, namely, the Southern Pacific and the Texas and Pacific and two of the principal roads on the left bank of the river, namely, the Illinois Central and the Mississippi Valley can be effected by a shorter line if the bridge be above the city. The representatives of the Illinois Central and of the Southern Pacific strongly favored the upper site, if a bridge is to be built. The agent of the Louisville and Nashville Railroad and of the Northeastern Railroad preferred a bridge below the city, both of these roads entering the city from that direction. Mr. John Glynn, jr., agent of the Northeastern Railroad Company, however, subsequently withdrew his letter in favor of the lower site.

Looking at the general railroad interests involved, the upper site ap-

pears to be the better. It should be stated, however, that none of the railroad companies represented before the Board urged the necessity of a bridge and the representative of the Illinois Central Railroad expressly disclaimed holding that opinion.

The plans submitted by Mr. Corthell, president of the Southern Bridge and Railway Company for a bridge above the city in the straight reach between Nine Mile Point and Twelve Mile Point, provide for but three spans, but two piers being in the river between the low-water lines. The river width at low water is about 2,600 feet. They provide for shore spans of not less than 800 feet and not less than 75 feet height above extreme high water and for a central height of center span not less than 82 feet. The Board proposes to increase this central height of the central span to 85 feet and to require that the 800 feet spans be in the clear at low water.

If the navigation by river steamers above the city alone be considered, these dimensions thus modified seem to be sufficient. It may be remembered, however, that cities are usually ultimately built as far inland as ocean vessels can penetrate. This would make a port possible far above New Orleans for deep-draught vessels at all stages of water. With the present size of New Orleans another port above it is scarcely probable; if it were, this bridge should be high enough to accommodate ocean commerce. Should a demand for a higher bridge arise section 8 of Senate bill 3901 provides a method for giving it such height.

The plans for a draw-bridge near the lower limit of the city were submitted by Mr. T. C. Clarke, engineer for the New Orleans Terminal and Railway Bridge Company. He proposes two pivot spans, giving three draw openings; namely, a central one of 464 feet in the clear, bridged by the ends of the two pivot spans meeting each other at the center; and two lateral openings of 224 feet each in the clear. The height of the bridge above high water to be 20 feet in the clear. With the amount of commerce which would have to pass through this bridge already stated as over 2,000,000 tons annually, such a bridge would be an obstruction, and fogs, which at certain seasons of the year are common, while they might not prevent the navigation of an open river, would make the passage of a draw-bridge impracticable. In the year ending May 31, 1889, about 1,300 steam and sailing vessels arrived at New Orleans from below, and this number should be doubled for passages in both directions. The average number of luggers arriving is about seven per day for the whole year, making 14 passages in the two directions. As the ocean commerce of New Orleans is largely concentrated into about four months, when cotton is moving, it is probable that the draw would have to be opened at such times thirty or forty times a day, mainly in the day-time, or often three openings per hour. As the time required for passing the draw would equal ten or fifteen minutes, it is seen that the draw would have to be open at such seasons one-half or three-fourths of the time. On days when six hundred cars were transferred, as estimated by Mr. Hutchinson, the equivalent in trains of fifteen cars would be forty trains. As these would be much concentrated at certain periods of the day when several trains would cross per hour, it is seen that there must be inevitable interference either with the movement of trains or with that of vessels. When it is further considered that the business and prosperity of the Southwest is rapidly increasing, and that still larger demands for facilities for commerce both upon the river and across it will come in the near future, the Board is of opinion that neither this draw-bridge nor any other should be permitted between New Orleans and the sea. Any bridge is an obstruction. But one bridge is

needed (if, indeed, that one be at present needed) for railroad purposes at New Orleans, and that should be above the city.

C. B. COMSTOCK,
Colonel of Engineers, Bvt. Brig. Gen.
CHAS. J. ALLEN,
Major of Engineers.
DAN C. KINGMAN,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

Y Y 2.

REPORT OF BOARD OF ENGINEERS ON H. R. BILL NO. 10437, FIFTY-FIRST CONGRESS, FIRST SESSION, TO AUTHORIZE THE CONSTRUCTION OF A HIGH LEVEL BRIDGE ACROSS THE MISSISSIPPI RIVER AT OR NEAR THE LOWER LIMITS OF THE CITY OF NEW ORLEANS, LOUISIANA.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C. June 18, 1890.

SIR: I have the honor to acknowledge reference to this office of letter of the 3d instant, from the Committee on Commerce of the House of Representatives, inclosing for War Department views thereon, H. R. 10437, Fifty-first Congress, first session, "A bill to authorize the New Orleans Terminal Railway and Bridge Company to construct, operate, and maintain a bridge, and all the necessary approaches thereto, over the Mississippi River from or near the lower limits of the city of New Orleans, State of Louisiana, on the left bank of the Mississippi River to the opposite bank in said State."

The bill was referred for consideration and report to a Board of Engineers, and a copy of the report of the Board dated June 14, 1890, is herewith submitted, from which it will be seen that the Board is of the opinion that no bridge should be permitted to be built at or below the city, but that the bridge described in the bill might be built above the city without seriously obstructing navigation, but it remarks that the curved form of the lower chord is objectionable, and will require special precautions to prevent it from being dangerous. The lower chord should be horizontal to make the entire width of water-way under the spans available for navigation.

The views of the Board of Engineers are fully concurred in by me and it is further recommended that addtional sections be incorporated in the bill providing for the maintenance of such light or other signals on the bridge as may be prescribed by the Light-House Board, and reserving to Congress the right to alter, amend, or repeal the act.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

REPORT OF BOARD OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
New Orleans, June 14, 1890.

GENERAL: The Board of Officers convened by Special Orders No. 29, Headquarters Corps of Engineers, June 4, 1890, to consider and report on H. R. bill No. 10437, Fifty-first Congress, first session, met in public session after due notice at New Orleans on June 12, 1890.

The Board heard the representatives of the various interests involved and allowed the fullest range to the discussion of the whole subject, and all letters and written reports pertaining to the matter which were laid before the Board were read aloud in the public session. After maturely considering the matter before it, the Board has the honor to submit the following report:

H. R. bill No. 10437 authorizes the construction of a high level bridge with continuous spans from or near the lower limits of the city of New Orleans, State of Louisiana, to the opposite bank in said State. It provides that the bridge shall have but two main piers in the river, that the clear distance apart of the piers of the central span shall not be less than 1,150 feet, and that the shore piers shall be beyond the lines of the shore at ordinary stages of the water; that the clear height of the central span shall not be less than 165 feet at the center, and not less than 150 feet for distances not less than 250 feet on each side of the center; and not less than 120 feet for distances not less than 450 feet on each side of the center. That the height of the side spans shall not be less than 120 feet at the shore piers, all to be taken from the level of high water as fixed by the Mississippi River Commission.

It appears from the evidence presented to the Board that it is doubtful whether any bridge is at present needed at New Orleans. Certainly not more than one bridge is required. The principal users of a bridge would be the railroads, and for these a location above the city would be far preferable to a location below.

The commerce to be impeded by a bridge at or below the city is the ocean commerce of the port; that by one above the city is the inland trade by river. One or the other must suffer somewhat from any bridge. The former is of greater importance than the latter, while at the same time it will suffer more from the obstruction offered by this bridge than the river navigation would suffer from a properly designed bridge above the city.

It must be sufficiently obvious that the growth and material prosperity of New Orleans depends, and must depend, mainly upon her ocean commerce. Without this her inland commerce would largely diminish; and anything, therefore, which tends to injure, inconvenience, or retard the free movement of sea-going vessels of any kind which now frequent her port will, by increasing marine risks, tend to drive the vessels to other markets.

That such effect will be necessarily produced, to a greater or less extent by the proposed bridge, or in fact by any practicable bridge located either in front of or below the city, admits of no doubt whatever. Large sea-going vessels are extremely difficult to handle safely in a narrow river with as strong a current as that of the Mississippi at New Orleans. They are built for use on the open ocean, and both the ships and their crews are greatly at a disadvantage under conditions so different from those to which they are ordinarily subject. The difficulty of turning around in a narrow river, under frequent conditions of wind and cur-

rent, of navigating large ships safely through the waters of a crowded port, and the dangers and delays inevitable from the frequent fogs, would all be greatly increased by the presence of bridge piers in the river and by the existence of a structure which must be passed in a certain definite way to insure safety. Moreover, the height of the proposed structure, great as it is, is not sufficient to pass many vessels now coming to ports of the United States, many of which have masts exceeding 165 feet in height.

Of the 1,424 sailing vessels of over 800 tons entering and clearing at New York in 1889, about one-eighth carried masts exceeding 165 feet in height, and 76 of them carried masts exceeding 175 feet in height. It seems probable that the future trade of New Orleans when fully developed will employ the same size of vessels as those now visiting New York.

The Board is therefore of the opinion that no bridge should be permitted to be built at or below the city.

The projectors of the bridge have offered to build it above the city if permitted to do so.

The central height, 165 feet, largely exceeds the requirements of navigation for that portion of the river, while the clear width of channelway within which a proper head-room will be provided, is sufficient.

The Board is therefore of the opinion that the bridge described in the bill might be built above the city without seriously obstructing navigation. But it thinks proper to remark that the curved form of the lower chord is objectionable and will require special precautions to prevent it from being dangerous. The lower chord should be horizontal, to make the entire width of water-way under the spans available for navigation. Equal or better accommodations for navigation could, no doubt, be obtained with a form of bridge which would be more satisfactory to the railroads and would cost less. It is only in view of the great width of water-way proposed between piers that the Board fails to condemn this type of bridge in this case.

The provision usual in bridge charters that the bridge company be required to maintain lights upon the bridge is not found in this bill. it should be introduced.

C. B. COMSTOCK,
Col. of Engineers, Bvt. Brig. Genl., U. S. A.
CHAS. R. SUTER,
Lieut. Col. of Engineers.
O. H. ERNST,
Major of Engineers.
CHAS. J. ALLEN,
Major of Engineers.
DAN C. KINGMAN,
Capt. of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

Y Y 3.

REPORT RESPECTING THE PRACTICABILITY AND NECESSITY OF A BRIDGE ACROSS DETROIT RIVER AT DETROIT, MICHIGAN.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 2, 1889.

SIR: To comply with request contained in resolution of the Senate Committee on Commerce of February 1, 1889 (herewith returned), a Board of Engineers was appointed by authority of the Secretary of War "to investigate and report upon the practicability and necessity of a bridge across the Detroit River at Detroit, Mich.," and I have the honor to submit the accompanying copy of the report, dated July 19, 1889, from the Board on the subject referred to.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

REPORT OF BOARD OF ENGINEERS.

ENGINEER OFFICE, U. S. ARMY,
Detroit, Mich., July 19, 1889.

SIR: The Board of Officers of the Corps of Engineers constituted by Special Orders No. 15, Headquarters Corps of Engineers, February 8, 1889, to investigate and report upon the practicability and necessity of a bridge over Detroit River at Detroit, Mich., has the honor to submit the following report:

Due notice of the meeting was given by advertisement in newspapers of Detroit, Cleveland, Buffalo, and Chicago, and by special notification to the Lake Carriers' Association, the Cleveland Vessel-Owners' Association, the Duluth Chamber of Commerce, the Michigan Central Railroad Company, and others, as well as the representatives of the winter bridge project, all of whom were requested to present views upon the subject. All of these associations as well as other interests responded by sending officers or attorneys to represent them before the Board, or by written communications, which will be found in the appendices herewith.*

The Board assembled at Detroit, May 1, 1889, at 10 o'clock a. m., and, after considering the papers referred to it by the Chief of Engineers, proceeded to an inspection of Detroit River on the steamer *T. W. Palmer*, being accompanied by a number of persons interested in shipping.

On the 2d the Board re-assembled at the U. S. Engineer Office, Detroit, and remained in session daily (Sunday excepted), hearing the evidence submitted by the different interests involved, until the evening of the 8th, when it adjourned to meet at the call of the Chief of Engineers, after the completion of the record of proceedings by the stenographer.

During this session the Board made several independent examinations of the river in front of the city of Detroit by day as well as by night.

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* Not printed.

The Board reconvened at Detroit July 16 in accordance with Special Orders No. 42, Headquarters Corps of Engineers, July 1, 1889, for consideration of the papers and evidence that had meanwhile been put into proper shape for examination and discussion.

The letter of the Hon. William P. Frye, chairman of the Committee on Commerce of the United States Senate, to the honorable Secretary of War, dated February 1, 1889, submitting resolution of that committee requesting the appointment of a Board of three Army Engineers to investigate and report upon the subject of this bridge, requests information not only as to the practicability and necessity of a bridge across Detroit River at Detroit, but also as to its feasibility, the best plan for a bridge, as well as to which would be the most practicable and most conservative of the shipping interests using the water of "said stream," and that the Board report the reasons submitted to them, for or against the construction of a bridge, and their own opinion thereon.

The information required to enable the Board to report in accordance with the terms of the resolution necessarily covered a great deal of ground, and called for extensive investigation as to the magnitude and value of the interests involved.

Detroit River is a part of the channel connecting Lakes Huron and Erie, and through which nearly all the shipping of the Great Lakes passes, an interest comprising about three thousand vessels of all sizes, and aggregating, in value, nearly $50,000,000.

Through this channel passes nearly all of the iron ore, most of the wheat and other productions of the States of Winconsin, Minnesota, Michigan, Illinois, Iowa, Dakota, and Montana, en route for Eastern markets, and, in return, coal and merchandise from the Eastern States to supply the demands of the Northwest.

At right angles to this stream of commerce are the railroads crossing at Detroit, forming lines of passenger and freight traffic between the east and west. The passenger and freight cars are ferried across the river, encountering no delay during the season of navigation, but being more or less delayed by ice from December to April, the period when navigation of the lakes is closed.

To remedy the delays and difficulties encountered more or less in winter by the railroads, the project of crossing the river by a bridge or tunnel has been several times brought forward, notably in 1873 and 1879. (See House Ex. Doc. No. 64 Forty-third Congress, first session, and Senate Ex. Doc. No. 9, Forty-sixth Congress, second session.)

It is asserted by the railroad interests that the delays and their consequent losses during severe winters at times amount to no less than $150,000, and that this sum does not begin to measure the degree of damage that the traveling and shipping public suffer thereby. In proof of this assertion are the statements offered in the argument of Mr. Henry Russel before the Board at its meeting in May.

To meet their alleged difficulties the plan for a winter bridge is presented among others, and will be referred to again.

Spanning the river by any structure that will encroach upon the bed of the stream is strongly opposed by the shipping interests on the ground that they will be materially injured through such an obstruction to navigation.

To reach a conclusion as to the necessity for a bridge across Detroit River at Detroit, it is necessary to consider all alternative propositions relative to means for transferring railway trains from one side to the other.

The question must always include three methods: First, underneath

the navigation (tunnels); second, on the surface (ferries); third, above the surface (bridges); and this last method may be divided into three, *i. e.*, high bridges, with permanent spans; low bridges, with draw spans (ordinary draw-bridges); low bridges with removable spans (winter bridges).

Considering these methods in their order, we have

(1) TUNNELS.—The use of a tunnel was urged in a general way, but with the exception of the project submitted by Mr. Luther Beecher, no definite plan for one was laid before the Board. The provisional directors of the Canada and Michigan Tunnel Company submitted an argument in favor of a tunnel, with an estimate of cost, but without indicating a plan by which their proposition was to be carried into effect. They asserted their ability to construct a tunnel within two years, of sufficient capacity to accommodate all the railway traffic, and at a cost not to exceed $4,000,000. This is understood to be exclusive of the approaches. The shipping interests would not interpose any objection to the construction of a tunnel, and there appears to be nothing urged against one, except (by the railroad and bridge interests) the uncertainty as to its cost and the possibility that an attempt to construct one might end in failure.

The Board does not doubt the practicability of constructing a tunnel at this point. Its cost, however, might be so great and the objections to operating it so considerable as to render the construction of doubtful expediency.

(2) FERRIES.—The present mode of transfer is by ferries, consisting of large and powerful boats carrying from fourteen to twenty-one cars at a time. These serve well their purpose during the season of navigation, but in severe winters are seriously impeded by ice. It is claimed by the Michigan Central Railroad Company that they have already expended large sums of money in building boats of the size and strength supposed to be necessary to make the crossing at all times and in all conditions of the ice, and that their last effort in that direction was the construction of a boat costing $287,000, which does not fulfill the requisite conditions.

Last winter was unusually mild, and there really was no formation of ice sufficient to test the capabilities of this latest boat. It is a fact that the passenger ferry-boats crossing the river less than a mile above the route of the Michigan Central Railroad Ferry are seldom materially impeded. They are much lighter boats than those used, or possible to be used for the railroad ferry, and carry no burden of any consequence. They have spoon-shaped bows, are driven by powerful machinery, and seem to make their way through the ice by being forced upon and breaking it down progressively by the weight of the boat. This seems to indicate a possibility of securing better results in the transportation of cars by using more powerful boats, properly designed.

One source of difficulty in the use of a railroad ferry arises from the clogging of the landing-slips by broken ice, which through repeated forcing of the boats in making a landing is compacted into a mass extending downwards to the bottom of the river, and outwards sufficiently far to prevent connecting the boat with the landing stage. The trouble is a real one, but it has not been demonstrated that the difficulties are of such a character that they can not be overcome without the construction of a bridge. It is claimed, however, by the persons representing the bridge and railroad interests that their efforts to secure prompt and satisfactory transit for cars have thus far failed and that the detention and delay are largely due to the causes stated.

(3) BRIDGES.—*High bridges.*—Owing to the character of the formation at the locality, it does not seem practicable to construct a suspension bridge covering the entire width of the river with a single span. The anchorages required would be so massive as to carry the cost of such a bridge beyond any possibility of profitable return. Mr. G. Lindenthal presented the only design for a high bridge submitted to the Board. He proposed a continuous girder bridge consisting of a central span of 1,000 feet clear opening, with two side spans 750 feet in the clear, the bottom chord being at a clear height of 140 feet above the water in the river, at the center of the long span, and accompanied his proposition by an elevation of the bridge with profile and strain sheet.

The bridge would have two piers in the river. The shipping interests oppose this bridge, claiming that its piers, one of which would be in the middle of the present main channel, would present so serious an obstruction to navigation that it ought not to be built. They also object to the proposed height of the bottom chord as not sufficient to permit the passage of all vessels now navigating the lakes.

The railroad interests object to the cost of such a bridge, which Mr. Lindenthal estimates at $6,000,000 exclusive of the cost of the land required for the approaches. They also object to the length and grade of the approaches, which would have to be nearly 1½ miles long with a grade of 1.7 per cent. or nearly 90 feet to the mile. Any reduction of grade would increase the length of the approaches.

Mr. Lindenthal, in his paper appended hereto, states that capitalists stand ready to build the bridge and throw it open to the use of all railroads at a charge of 62 cents per car for passage, and claims that at this rate the owners would receive a fair return for their investment. He compares this charge with the combined cost of transfer by ferry during the summer and low bridge during the winter, with results favorable to the high bridge.

Mr. Lindenthal also claims that his bridge would permit the passage of trains at any ordinary speed, and that in consequence the delays inherent in any of the proposed means of transfer would be reduced to a minimum.

Upon investigation the Board finds that the two piers would together obstruct only about 4,480 square feet, or about 6 per cent. of the area of the cross-section of the river at the proposed location of the bridge, and where there is an ample depth of water.

The objection raised by the shipping interests to the proposed headway of 140 feet is not considered important. The number of vessels now on the Lakes with masts higher than 140 feet is small, and they can readily conform to this height.

The Board is of opinion that while any bridge with piers in the river would necessarily be to some extent an obstruction, yet this bridge, with the spans proposed, would offer the minimum impediment possible in the present state of the art of bridge construction, and the demand for this concession to the railroad interests is considered a reasonable one. The Board does not consider that the objections presented to a bridge of this character are of sufficient force to be prohibitory.

Low bridges.—Draw-bridge.—It is now admitted by all concerned that an ordinary draw bridge across Detroit River is quite inadmissible, and, therefore, no time need be occupied in discussing questions relating to such a bridge.

Winter bridge, or bridge with removable spans.—Three plans were presented by Mr. W. K. Muir and his associates, as follows, viz:

No. 1. With one clear opening of 1,000 feet, four clear openings of 200 feet each, and three fixed spans of 200 feet each, involving the use

of seven piers rising above the surface, and three piers submerged to a depth of 30 feet.

No. 2. With one clear opening of 1,000 feet, one clear opening of 732 feet, two clear openings of 200 feet each, and two fixed spans (at the shore ends) each 159 feet long in the clear, involving the use of five visible piers and five piers submerged to a depth of 30 feet.

No. 3. With two openings of 1,000 feet each between centers of piers, two openings of 150 feet each between centers of piers, two openings of 150 feet each from centers of piers to faces of adjacent abutments, and involving the use of five visible piers and four piers submerged to a depth of 30 feet.

They propose, in each case, that all the swing and removable spans shall be open during the entire period of navigation, and the bridge be used for crossing the river only when navigation is suspended, thus giving vessels the undisputed right to the river navigation, impeded only by such piers as rise above the surface, or by such fixed spans as are indicated, the openings to be suitably lighted, and tugs to be in readiness if necessary to aid rafts in passing the large openings.

Of these three projects the Board considers the one numbered 2, having four openings of 1,000 feet, 732 feet, 200 feet, and 200 feet, respectively, as the least objectionable, and are of opinion that a bridge of that kind, operated only during the winter season, would be sufficiently conservative of the shipping interests, and would not be an unreasonable obstruction to navigation, provided that these openings for their entire width shall be available from the 1st of April to the 1st of December, and the side spans of 200 feet shall be opened between December 1 and April 1 whenever vessels desire to pass; and provided further, that the piers and superstructure shall be lighted from sunset to sunrise as may be required by the Light-House Board, and that no other bridge shall be built across Detroit River within 10 miles of this one. This bridge to be available for the use of all railroads that may desire to cross it with trains, cars, or locomotives, on payment of a reasonable charge for such use of the bridge, the amount to be fixed by the Secretary of War. The tops of the permanent foundations of the movable supports of the bridge to be at least 30 feet below low water; and the bridge itself to be at right angles with and its piers and the draws or trusses when swung open to be parallel in direction to the current of the river. The right of the Government to be reserved to alter or amend the franchise, or to require the removal of the bridge and piers in case it should be deemed necessary to do so.

The project No. 3, although proposing two spans of 1,000 feet each between centers of piers, and having five fixed piers, is more objectionable than No. 2, for the reason that it does not provide for removing clear of the river any portion of the superstructure. Under project No. 3, the long trusses, when swung open, would extend 575 feet down stream beyond the axis of the bridge, obstructing to that extent the crossing, and screening from the view of both ascending and descending vessels greater areas of the harbor than would No. 2, the longest trusses of which, when swung, would extend down stream but 200 feet.

The foregoing remarks relate more particularly to the question of the feasibility of bridging Detroit River without unreasonably interfering with its navigation.

In regard to the necessity for a bridge it was stated by Mr. O. D. Conger, attorney for the vessel interests, that 389,239 cars were transported across the river by ferry in 1887, and 374,426 cars in 1888, or an average of more than a thousand cars per day.

The number of passengers transported across the river by the Michigan Central Railroad Company in 1888 was 261,470.

The number of cars crossing by the Michigan Central Ferry in the months of January, February, March, and December, 1888, was 97,002, and the number of passengers crossing during the same months was 62,747.

The Board regret that corresponding statistics were not supplied them for the other railroads crossing Detroit River.

The number of cars crossing by the same ferry during the months of June, July, August, and September, 1888, was 95,971, and the number of passengers was 120,642.

It thus appears that whilst the number of cars ferried during the four months of assumed closed navigation was actually slightly in excess of those transferred during the four months of open navigation named, the number of passengers was but little more than one-half.

The representatives of the railroad interests claimed that this difference in the volume of the passenger traffic was largely due to the disinclination of passengers to incur the risk of detention through delays in ferrying at Detroit, and it is to secure prompt and certain passage that a bridge is proposed for use during the winter, when navigation is suspended.

The claims of the railroad interests in this regard are clearly set forth in the remarks submitted by Mr. Henry Russell, attorney for the Michigan Central Railroad.

The facts developed show conclusively that a method of crossing Detroit River which shall always and under all conditions be perfectly trustworthy is of the greatest consequence to the railroad interests centering at Detroit, but they do not demonstrate such a degree of necessity as to imperatively demand that it shall be by means of a bridge, much less by a so called winter bridge. If no other way were possible the question would be relieved of all doubt, and the interests of the general public would so loudly demand a bridge as to overcome the opposition of the shipping interests, and the latter would have to submit to the resulting inconvenience for the general welfare.

The Board, following the requirements of the Senate Committee on Commerce, report—

First. In their opinion it is feasible to build a bridge across Detroit River at Detroit, Mich.

Second. That of the projects for a bridge submitted to them, that for a high bridge proposed by Mr. Lindenthal is the least objectionable and the most conservative of the shipping interests, and therefore the best plan.

Third. That project No. 2 for a winter bridge is the most practicable because it will accomplish the result sought at less cost, though justly subject to greater objection upon the part of navigators. The Board desires not to be understood, however, as indorsing the estimate of cost of the winter bridge as submitted by its projectors.

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All of which is respectfully submitted.

O. M. POE,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.
CHAS. J. ALLEN,
Major of Engineers.
H. M. ADAMS,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

Y Y 4.

REPORT ON THE PRACTICABILITY AND APPROXIMATE COST OF TUNNELING THE DETROIT RIVER AT OR NEAR DETROIT, MICHIGAN.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., May 6, 1890.

SIR: For the purpose of complying with the provisions of the joint resolution approved April 19, 1890, the Board of Engineers, constituted by Special Orders, No. 15, Headquarters, Corps of Engineers, February 8, 1889, to investigate and report upon the practicability and necessity of a bridge across the Detroit River at Detroit, Mich., was, by direction of the Secretary of War, reconvened by Special Orders, No. 21, Headquarters, Corps of Engineers, dated April 21, 1890, to consider and report upon public resolution, approved April 19, 1890, "Requesting the Secretary of War to cause a further report to be made as to the practicability and approximate cost of tunneling the Detroit River at or near Detroit, Mich."

The report of the Board, dated May 3, 1890, has just reached this office, and a copy, with its accompanying papers, is submitted herewith, from which it will be seen that in the opinion of the Board the construction of the tunnel is practicable at an estimated cost of $3,500,000 (exclusive of land damages) for a single-track railway, and that there is no objection to authorizing its construction under the bed of the river.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

REPORT OF BOARD OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., May 3, 1890.

SIR: Complying with the provisions of joint resolution of Congress approved April 19, 1890, the Board of Engineers convened by Special Orders, No. 21, Headquarters, Corps of Engineers, April 21, 1890, has the honor to submit the following report:

The Board met at Detroit, Mich., April 30, 1890, at 10 a. m., all the members being present. The following instructions were read, viz:

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., April 23, 1890.

COLONEL: The accompanying copy of public resolution No. 14, entitled, "Joint resolution requesting the Secretary of War to cause a further report to be made as to the practicability and approximate cost of tunneling the Detroit River at or near Detroit, Mich.," approved April 19, 1890, is furnished for information of, and consideration by, the Board of Engineers constituted by Special Orders, No. 21, Headquarters, Corps of Engineers, April 21, 1890, of which you are the senior member.

The duties of the Board and the information desired are so clearly stated in the resolution that no supplementary instructions by this office are deemed necessary.

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By command of Brig. Gen. Casey:
Very respectfully, your obedient servant,

THOS. TURTLE,
Captain, Corps of Engineers.

Col. O. M. POE,
Corps of Engineers.

[Public resolution No. 14.]

JOINT RESOLUTION requesting the Secretary of War to cause a further report to be made as to the practicability and approximate cost of tunneling the Detroit River at or near Detroit, Michigan.

Whereas there having been commissions of Army engineers appointed in the years eighteen hundred and seventy-three, eighteen hundred and seventy-nine, and eighteen hundred and eighty-nine to investigate and report upon the necessity and practicability of the proper means of crossing the Detroit River at or near Detroit, Michigan, by bridge or otherwise; and

Whereas said commissioners have limited such investigations more particularly to the question of bridging said river: Therefore,

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War is hereby directed to have the said Board of Engineers appointed by the Secretary of War in 1889 to more fully report upon (at the earliest time practicable) the advisability, practicability, and approximate cost of tunneling the Detroit River at or near Detroit, Mich., in such a manner as to accommodate the large trade and commerce crossing the river at that point without permanent obstruction of any kind whatever to the navigation interests of said river, with a view to the passage of said commerce through said tunnel from the United States into and through the Dominion of Canada, and return; such report to be based upon the examination already made by said Board, or, if necessary to a compliance with this resolution, to make such report after further inquiry into the subject.

Approved April 19, 1890.

The duties of the Board appear to be comprehended in the requirement that they shall report upon—

The advisability, practicability, and approximate cost of tunneling Detroit River, at or near Detroit, Mich., in such a manner as to accommodate the large trade and commerce crossing the river at that point, without permanent obstruction of any kind whatever to the navigation interests of said river.

The Board remained in session four days, devoting two days to listening to such persons as desired to furnish information or present their views upon the subject.

Mr. Luther Beecher and Dr. Sherman appeared before the Board and explained their respective plans for constructing a tunnel under Detroit River, and Mr. L. Grover partly explained a method of his own for what he styled shallow tunneling, though he presented no plans or models.

Two copies of Mr. Beecher's patents are herewith marked A* and B*.

A communication, with blue prints, from U. S. G. White, civil engineer, U. S. Navy, was received. A circular from Mr. Charles H. Buckelew, explaining his proposed method of tunneling, and a letter from Mr. R. P. Rothwell, inviting attention to the Hall method of tunneling, were also received. These papers* are herewith, marked C, D, E, and F.

The Board personally examined a tunnel for a single-track railroad now in progress under St. Clair River at Port Huron, Mich., which, when completed, will be about 6,100 feet long, a part of the tunnel being under the river banks. The width of the river at this point is 2,300 feet, and the tunnel work has been advanced 200 feet under it on the Michigan side and has reached a point 100 feet short of the bank of the river on the Canada side. The tunnel is being pushed forward at the rate of 16 to 20 feet a day, 8 to 10 feet on each side of the river, and it is expected that it will be completed in six months. It seems probable that it will be opened for traffic in 1891. The estimated cost of this work, as published in a technical journal, is $2,500,000. The material through which a tunnel under Detroit River, at Detroit, would have to

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* Omitted; printed in House Ex. Doc. No. 369, Fifty-first Congress, first session.

be constructed, is similar to that through which the St. Clair River tunnel is now being successfully pushed forward toward completion.

Taking up the subjects for report, as required by the joint resolution, in their order, the first that presents itself is that of the advisability of tunneling Detroit River at or near Detroit. The advisability of selecting any particular mode of crossing the river depends very largely upon the amount and character of the traffic to be provided for, coupled with the comparative cost of crossing by different modes having sufficient capacity to pass the traffic.

It is stated in the report of this Board dated July 19, 1889, that 389,239 cars were transported across the river by ferry in 1887, and 374,426 in 1888, or an average of more than 1,000 cars per day. The reasons advanced for the necessity of some crossing other than by ferry are also stated in that report, so that it is not necessary to dwell upon that question in this paper.

As railroad traffic across the Detroit River increases, the disadvantages of the ferriage system will increase.

The erection of any bridge across the Detroit River will always be more or less objectionable to navigation interests, and even if a high bridge were unobjectionable, its cost, including approaches, would undoubtedly be in excess of the cost of two single-track tunnels.

So far as the interests of navigation are considered, the construction of a tunnel would undoubtedly be advisable, but whether it would be correspondingly advantageous to the railroad interests will depend on the cost of a tunnel.

The Board is of the opinion that there is no objection to the authorization by Congress of the construction of a tunnel under the bed of the river, but at no point with less than 30 feet of water over its top, by any railroad or corporation interested. All railroads should be permitted to pass cars through the tunnel on payment of a reasonable and fixed charge to be determined by the Secretary of War.

In regard to the practicability of making a tunnel under the Detroit River, the Board is of the opinion that the recent progress made in the construction of subaqueous tunnels through difficult materials in England, under the Hudson at New York, and under St. Clair River at Port Huron, demonstrates the practicability of constructing a tunnel at Detroit where the material through which a tunnel is proposed is not believed to be more difficult than that at Port Huron.

And it is the further opinion of the Board that $3,500,000 will cover the cost of a tunnel for a single-track railway under Detroit River. This estimate includes the cost of approaches, but not the cost of land damages, which will depend upon the location of the tunnel.

All of which is respectfully submitted.

O. M. POE,
Colonel, Corps of Engineers, etc.
CHAS. J. ALLEN,
Major, Corps of Engineers.
H. M. ADAMS,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

YY 5.

REPORT OF BOARD OF ENGINEERS ON PLANS AND LOCATION OF PROPOSED BRIDGE ACROSS OHIO RIVER BETWEEN LOUISVILLE, KENTUCKY, AND JEFFERSONVILLE, INDIANA.

WASHINGTON, D. C., *March* 16, 1889.

SIR: On the 15th instant we presented a communication addressed to you, of which the following is a copy:

UNITED STATES SENATE,
Washington, D. C., March 12, 1889.

DEAR SIR: We request you to detail a Board of Engineers to consider the questions involved in the proposed bridge between Louisville, Ky, and Jeffersonville, Ind., especially in reference to its alleged obstruction to navigation, and report the result to Congress at your earliest convenience.

Very respectfully,

WM. P. FRYE.	M. W. RANSOM.	A. P. GORMAN.
JNO. P. JONES.	J. Z. GEORGE.	JNO. E. KENNA.
J. N. DOLPH.	J. DON CAMERON.	R. L. GIBSON.
PHILETUS SAWYER.	RICHARD COKE.	JOHN SHERMAN.
S. M. CULLOM.	G. G. VEST.	J. C. S. BLACKBURN.

As will be seen, this communication is signed by every member of the present Committee on Commerce of the Senate, except Senator Washburn, who was absent from the city. In addition to the members of the Senate committee, it bears the signatures of three Senators whose constituents are largely interested in the safe and free navigation of the Ohio River, Hon. John Sherman, Hon. J. Z. George, and Hon. J. C. S. Blackburn.

With a single exception every Senator was fully informed of the facts as contained in the official documents bearing upon the question—the reports of the two committees of the House and Ex. Doc. No. 29, having been before them at the time. It was signed with a knowledge of the fact that the plans for this bridge had already been approved by the late Secretary.

As some misapprehension seems to exist as to the object of the above communication, we desire to state that we respectfully ask in the terms of this request that you convene a Board of United States Engineers, familiar with the navigation of the Ohio River and the requirements of its commerce, who shall give full information to Congress upon all questions connected with this subject.

The plans have been approved, and as a legal proposition, they must, so far as the executive department of the Government is concerned, stand approved. We do not ask or expect any revocation or change of said plans by you. We claim, however, that the construction of this bridge upon the plans as approved will be a serious, unnecessary, and unreasonable obstruction to navigation, and we ask your aid only to the extent of furnishing full and accurate information, upon which we hope and expect the next Congress to take action.

The letter of March 5, 1889, signed by Hon. Benton McMillin, Hon. W. C. P. Breckinridge, and others, which doubtless was the cause of the misapprehension above alluded to, was written without the knowledge on the part of any of the signers, that the plans for the bridge had been approved. We are now informed that the late Secretary signed these plans on the 28th of February last and while the whole question was yet pending before Congress. It may be proper to state, upon the authority of the late Secretary, that when he acted upon this matter he was not informed of the fact that a vote upon the question had been

prevented in Congress by the single objection of a member who was at the time and is now a director of the bridge company.

As to your power to comply with the request of the Senate there can be no question. Undoubtedly the Secretary of War can order a Board of Engineers as asked for here at any time. We know of no instance where a request of this kind, even in an ordinary case, has been refused. Only a few days ago, as we are informed, upon the request of one of two Senators, a Board was ordered to convene at Detroit. Such boards have been convened even when the bridge had been authorized by an act of Congress and partially completed upon plans approved by the War Department. Only a year ago upon the request of the Committee on Commerce of the Senate, a Board of Engineers was convened by Special Orders, Nos. 8 and 9, to "investigate the alleged obstruction to navigation of the bridge in process of construction across the Staten Island Sound, known as "Arthur Kill." (See Annual Report Chief of Engineers for 1888, appendix W W 2, page 2421.) The Board, upon which was the present distinguished head of the Engineer Department, General Casey, was also asked to "advise the committee as to the necessity of the bill (S. 1842) or other legislation."

There are several points in this case which make it stronger than the one now under consideration. It was authorized by an act of Congress. The "plans of construction were approved by the War Department after a long and full hearing from both sides." The Senate had rejected a bill "identically the same as the one the Board was requested to consider." The bridge company had "proceeded in good faith with the construction of this bridge upon what it could very naturally regard as a final decree or judgment." At the time the Board convened it had "erected piers as authorized, and expended a large amount of money in so doing, and also for shop work, on the superstructure then nearly completed." The "pivot pier was completed and the crib work support, for the draw when open, built to about 5 feet above high water. Both the abutment piers had been finished. The caissons were in position, but had not been settled." We quote from the reports of the Board.

The bridge at Louisville owes its existence not to a direct act of Congress but to a general law, variously construed by the best lawyers, whose requirements must be strictly complied with to secure a legal structure. Instead of being half built, the first spade of dirt has not yet been thrown, nor is it probable with a pending request for a Board of Engineers from every committee in both branches of Congress having jurisdiction of the subject, that any progress can be made until this is done. No adverse action as to the proposed board has been had in Congress, but as far as it could be done the reverse is true.

Under these circumstances we confidently hope for a prompt compliance with the request of the Senate committee. Such a result will, we submit, be to the interest of all parties, and is in strict accord with the precedents of the Department and the theory of governmental control over bridge construction.

Our rivers are the natural channels of inland commerce, and should be preserved. They are free to all, and can never become the property of powerful combinations and monopolies. For the protection of these great public highways we look to the War Department. To you, Mr. Secretary, under the laws of Congress, is confined the guardianship of these important interests, and when the demand, as in this case, is limited to a simple request for information touching an alleged serious obstruction to one of the greatest of these highways, at a point ad-

mitted to be the most dangerous in its whole course, we feel assured that it will be granted.

Very respectfully,

W. P. TAULBEE.
ALBERT S. WILLIS.

Hon. REDFIELD PROCTOR,
Secretary of War.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
April 13, 1889.

Respectfully returned to the Secretary of War.

It is entirely within the power of the Secretary of War to appoint a Board of Engineers to report on the plans and location of the proposed bridge over the Ohio River, between Jeffersonville, Ind., and Louisville, Ky., and it is accordingly recommended that a Board be appointed, to consist of Col. C. B. Comstock, Lieut. Col. Charles R. Suter, and Maj. C. J. Allen, Corps of Engineers.

With the approval of the Secretary of War the necessary order will be issued from this office.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

[Second indorsement.]

WAR DEPARTMENT,
April 16, 1889.

Approved as recommended by the Chief of Engineers.
By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

* * * * * * *

[Fifth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
September 24, 1889.

Respectfully returned to the Secretary of War.

The report of the Board of Engineers constituted in compliance with the foregoing (second) indorsement of the Secretary of War is herewith.

Under authority of the acts approved December 17, 1872, and February 14, 1883, relating to the bridging of the Ohio River the Secretary of War approved the plans and location for the proposed bridge across the Ohio River between Louisville, Ky., and Jeffersonville, Ind., on the 28th of February last. The plans were considered by a Board of Engineers, as required by law, and the report of the Board is published in House Ex. Doc. No. 29, Fiftieth Congress, second session.

The changes in plans suggested by the Board were made by the bridge company and the amended plans were approved by the Secretary of War as stated.

It will be seen by the accompanying letter of August 17, from Mr. Dennis Long, president of the Louisville and Jeffersonville Bridge Company, that the company after receiving from the War Department the

approved plans invested in land and contracted with the Phœnix Bridge Company to build the bridge.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

REPORT OF BOARD OF ENGINEERS.

LOUISVILLE, KY., *September* 14, 1889.

GENERAL: The Board of Officers of the Corps of Engineers, convened by Special Orders No. 34, Headquarters Corps of Engineers, April 19, 1889, to report on the plans and location of the proposed bridge across the Ohio River between Jeffersonville, Ind., and Louisville, Ky., has the honor to submit the following:

The Board assembled at the call of the senior member, at the United States Engineer office, 507 West Chestnut street, Louisville, Ky., at 11 a. m., September 11, 1889, and continued in session until the afternoon of September 14.

Due notice of the meeting was given by advertisement in Louisville, Cincinnati, and Pittsburgh newspapers, and special notice of the meeting was also communicated, in writing, to persons prominently interested in the location and construction of the proposed bridge.

The afternoon of the 11th and the morning of the 13th were given to personal inspection by the Board of the river in front of Louisville and Jeffersonville and of the approaches to the river from both cities.

The 12th was devoted to a public meeting, at the United States Engineer office, at which were present representatives of the bridge, river, and ferry interests. The Pittsburgh Coal Exchange was represented by its president.

The representatives of all these interests were invited to express their views in the matter, and to present any facts in their possession bearing upon the questions involved. Considerable verbal testimony was offered, which will be found in the stenographer's record, here appended.

The arguments of counsel for ferry interest, and the bridge interest, presented in writing, are also herewith.

The city of Louisville is situated on the south or left bank of the Ohio, and opposite the city of Jeffersonville. The Ohio River for 4 or 5 miles above these cities is straight, with nearly parallel banks. In front of the upper portion of the city of Louisville is Willow Island, separated from the Kentucky shore by a narrow channel. The average width of the river between this island and the Indiana shore, at low water, is about 1,650 feet. Below the island the width increases.

On the Jeffersonville side, and nearly opposite the lower end of Willow Island, the bank deflects to the right, forming a point which will be referred to further on.

The only means at present of communication between the two cities are the Fourteenth Street Railroad Bridge and the boats of the Louisville and Jeffersonville Ferry Company, which run from the foot of Fourth street in Louisville to Spring street in Jeffersonville.

The only definite bridge plan referred to the Board is that of the Louisville and Jeffersonville Bridge Company, for crossing the Ohio River from the foot of Mulberry street, Jeffersonville, to a point near the upper end of the city of Louisville, the bridge also crossing the lower end of Willow Island. This plan provides for a span of 650 feet

in the clear on the Indiana side and one of 400 feet in the clear on the Kentucky side, measured at low-water mark, and two intermediate spans, one of 250 and one of 300 feet, from centers of piers.

The site of this proposed bridge is 3,372 feet above the United States dam across the Falls of the Ohio. Just below the line of the bridge the Indiana shore curves to the right, forming the point already mentioned. The natural channel over the falls, knows as the Indiana Chute, is closed to the Indiana side, so that tows destined to cross the falls must round this point in such shape as to make that channel, in order to do which they must pass through an artificial opening 600 feet or less in width.

The important stage of water in the Ohio at Louisville known as the "boating stage" occurs when the water rises to about 11½ feet on the gauge, because at this stage coal tows of ordinary size go over the falls through the Indiana Chute.

Tows, in order to round the point and enter the Indiana Chute, have to flank more or less, an operation which is performed by allowing the tow to float at an angle with the current and backing the steamer when necessary. Failing to make the chute, they are liable to be broken up against the Government dam.

Coal fleets frequently run along Willow Island, and those destined for the canal take that shore.

The proposition to bridge the river at the foot of Mulberry street was reported upon, under date of June 1, 1888, by a Board of Officers of the Corps of Engineers. That Board disapproved of this site, in which disapproval the present Board concurs, for the reasons assigned by the previous Board, whose report may be found in Appendix No. 6, herewith.

The Board recommended a site at or above Wall street, in the city of Jeffersonville, in which recommendation the present Board also concurs. Such location would not only place the bridge above the ferry and steam-boat landings, but would insure its being sufficiently removed from the falls and from the contemplated extension 600 feet up-stream of the Government dam.

The principal objection made by the coal interests to locating a bridge above Mulberry street is that the bridge would be too near the lower end of their landing at the Pumpkin Patch. This disadvantage, however, is, in the opinion of the Board, more than counterbalanced by the greater distance of the bridge above the dam.

The relative importance of the channels leading to the canal and the Indian Chute depends upon the quantities of coal which go through them, and this, in turn, depends upon the stages of water in different years. Thus in the fiscal year 1887 25,000,000 bushels passed through the canal and 19,000,000 passed over the falls; while in the fiscal year 1889 about 56,000,000 passed through the canal and about 3,000,000 over the falls, 1889 being a very exceptional year as to stage of water.

These figures indicate that the Kentucky Channel span is of as much importance as that for the Indiana side.

A project is now under consideration for enlarging the capacity of the Indiana Chute, which, if carried into effect, will result in the passage of a much larger quantity of coal down that chute.

The Board is aware that the selection of a site for the bridge at or above Wall street will increase its cost; that increase is estimated in the appended paper, Appendix No. 1, by the president of the bridge company at $450,000 or $500,000. It is thonght that this estimate is

excessive, and that the interests of navigation demand of the bridge company the additional cost imposed by the upper site.

The Board has also received a letter from the president of the bridge company proposing to give but three river spans of about 550 feet each at the Mulberry-street site. Such a bridge would be an admirable one for the Wall-street site, but for the reasons already stated the Board does not recommend it for the Mulberry-street site. The Board therefore disapproves the Mulberry-street site, and recommends that the proposed bridge be at or above Wall street, with a channel span of at least 500 feet in the clear at the low-water line on the Indiana shore and a similar span on the Willow Island shore, the water face of the shore piers of these spans being at the low-water lines.

Respectfully submitted.

C. B. COMSTOCK,
Colonel of Engineers, and
Bvt. Brig. Gen.
CHAS. R. SUTER,
Lieut. Col. of Engineers, U. S. A.
CHAS. J. ALLEN,
Major of Engineers, U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

LIST OF APPENDICES ACCOMPANYING THE FOREGOING REPORT.*

Appendix 1. Letter of August 17, 1889, from Denis Long, president Louisville and Jeffersonville Bridge Company.
Appendix 2. Letter of August 20, 1889, from J. W. Baird, secretary Louisville and Jeffersonville Bridge Company.
Appendix 3. Letter of September 11, 1889, from C. M. Holloway, president United States Mail Line Company.
Appendix 4. Brief of September 12, 1889, of A. P. Humphreys.
Appendix 5. Brief of September 13, 1889, of Denis Long.
Appendix 6. Letter of September 14, 1889, from Denis Long, president Louisville and Jeffersonville Bridge Company.
Appendix 7. Stenographer's report of the public meeting.
Appendix 8. House Ex. Doc. No. 29, Fiftieth Congress, second session.

Y Y 6.

REPORT OF BOARD OF ENGINEERS RESPECTING BRIDGES ACROSS CHARLES RIVER, MASSACHUSETTS, INTERFERING WITH NAVIGATION.

CHARLES RIVER BRIDGE BOARD,
Boston, Mass., February 1, 1890.

GENERAL: The Board of Engineers, constituted by Special Orders, No. 82, Headquarters Corps of Engineers, U. S. Army, December 14, 1889, having performed the duties required of it, has now the honor to submit its report.

The minutes of evidence given at the public hearings in Boston (A), the arguments of counsel for the cities of Boston and Cambridge (B), a few other essential papers (C), will be found appended; also a litho-

* Not printed.

graphic copy of map of Charles River below West Boston Bridge, 1882.

The order convening the Board reads as follows:

Special Orders } HEADQUARTERS CORPS OF ENGINEERS, U. S. ARMY,
No. 82. } *Washington, D. C., December* 14, 1889.

By direction of the Secretary of War, a Board of Officers of the Corps of Engineers, to consist of Col. Henry L. Abbot, Lieut. Col. George L. Gillespie, Lieut. Col. Samuel M. Mansfield, will convene at Boston, Mass., at as early a day as practicable, upon the call of the senior member, to consider the bridges across Charles River, owned or controlled by the cities of Boston and Cambridge.

The expenses of the Board will be paid from the appropriation for improving Boston Harbor.

Upon completion of the duties assigned them, the members of the Board will return to their proper stations.

The journeys required under this order are necessary for the public service.

By command of Brigadier General Casey:

CLINTON B. SEARS,
Captain, Corps of Engineers.

The duties of the Board, contained partly in the order above given constituting the Board and partly in the letters of the Secretary of War to the councils for the cities of Boston and Cambridge, dated December 10, 1889, comprehend the examination of the bridges owned or controlled by the city of Boston alone, and of those owned or controlled by the cities of Boston and Cambridge jointly, with the view of determining if the said bridges form obstructions to the navigation of the Charles River, within the meaning and intent of sections 9 and 10 of the river and harbor act of August 11, 1888.

The Board had, during three days' public meetings in Boston, which had been advertised in the city papers, to ascertain the views of all interested parties, and every effort was made to determine the essential features of the bridges owned or controlled by the two cities, and the manner in which they affected the navigation of the river. An inspection was made also in connection with a committee representing the two cities of the entire bridge system from the Charles River Bridge to the newly-constructed bridge across Charles River Basin, called the Harvard Bridge, during which an opportunity was afforded to the Board to inspect the bridges at the draws and note the time actually consumed in maneuvering the draws by the bridge appliances.

The Charles River within the reach of 1½ miles, extending from its mouth to the outlet of Charles River Basin, is crossed by nine separate and distinct bridges, five of which are owned and controlled by railroad companies. The two bridges nearest the mouth of the river, which connect Boston with Charlestown, are known as the Charles River Bridge and the Warren Bridge, and are owned and controlled by the city of Boston alone. The two most western, at the entrance to Charles River Basin, which connect Boston with Cambridgeport and East Cambridge, and known as West Boston Bridge and Craigie's (Canal) Bridge, are owned and controlled by the cities of Boston and Cambridge jointly.

These four bridges are the ones which form the subject of this report The following is a description of these bridges:

CHARLES RIVER BRIDGE.

Entering the Charles River from Boston Harbor we first encounter the Charles River Bridge, about 2,300 feet from its mouth. This bridge was built in 1785–'86 and rebuilt 1854–'55, and connects Boston with Charlestown. It is a level wooden bridge but little above the plane of

high water, is 1,102 feet long between abutments, and 50 feet wide, with roadway, sidewalks, and two horse-railroad tracks, supported upon oak piles in bents with average bays of 15.9 feet from center to center—the least width of bay 5 feet, the greatest 25 feet—and has a draw opening of 36 feet. The height of the under side of the lowest stringer above mean high water is six-tenths of a foot. The height of bottom of the draw is 1.4 feet. The draw is of the slide or miter pattern, and consists of two plate-iron girders carrying trussed wooden floor beams, with a plank roadway. It has friction roller trucks, and is moved by steam-power and can be opened in less than a minute. Steam capstans assist vessels through, and the average time of passing a vessel is four minutes. Above this bridge we find a water basin with a valuable water frontage on the Boston side of about 630 feet, occupied by five wharves for the handling of coal, lumber, and cement, and 375 feet on the Charlestown side, almost exclusively devoted to the handling of coal, up to the Warren Bridge. The draw-rests of the two bridges approach to within about 160 feet of each other in mid-stream, and are relatively placed to best facilitate the passage of vessels through the two bridges. The anchorage capacity of the basin is limited to seven or nine vessels.

WARREN BRIDGE.

This bridge was built in 1828, and rebuilt in 1883–'84. Its width is 80 feet, and length between abutments 1,320 feet. It is a wooden structure with roadway, sidewalks, and two horse-railroad tracks supported upon oak piles in bents averaging 15.8 feet between centers; least width of bay 10 feet, greatest width 16½ feet. The bridge rises 5 feet from either abutment to the draw opening, which is 36 feet 3 inches in the clear. At the abutments the bottom of the lowest stringer is above mean high water 1.16 feet, and at the draw 6.16 feet.

The bridge supports iron pipes, connected with the water supply of the city, and the under side of the box inclosing these pipes is 2.48 feet above mean high water at the draw, fifty-two one hundredths feet below at the Charlestown end, and 4 feet below at the Boston end.

The draw is of the slide or miter pattern in two sections, both of which run off on the Charlestown side. They are moved by steam power, and can be opened in less than a minute; steam capstans are ready to assist vessels through the draw.

Just above this bridge the river is crossed by four railroad bridges, essentially parallel to each other, in juxtaposition, and joined to the Boston end of the Warren Bridge, occupying with the latter a front on the Boston side of about 950 feet, and on the other side of the river 2,000 feet. The Boston front is bridged over up to the draw openings so as to practically exclude this deep water frontage from commercial use, and the area so occupied is used by the railroads with their tracks as a switch yard. On the other side of the draw openings, which, with the exception of the Fitchburg, are a little less than 36 feet wide, the bridges are covered with rails and freight sheds; virtually they form the piers and docks for transshipment between vessels and cars, and are doubtless used in this manner to their full capacity.

The bridges are in the following order going up-stream: Fitchburg, Boston and Maine, Eastern, and Lowell Passenger. Miller's River on the north side, now a mere inlet or canal, about 3,000 feet long and 150 feet wide, is embraced between the railroads and their bridges, and affords a considerable wharf frontage.

A triangular water area lies above these bridges and between them

and the Lowell Freight Bridge, with about 750 front on the north side, but the water on this shore is shallow, and under existing circumstances is of limited commercial value; the railroad skirts it, as well as the small front on the Boston side. The draw opening in the Lowell Freight Bridge is less than 36 feet.

About 200 feet above this bridge and nearly parallel to it is Craigie's Bridge, a highway owned and controlled by the citizens of Boston and Cambridge.

CRAIGIE'S (OR CANAL) BRIDGE.

This bridge was built in 1808, and repaired in 1873. Its length between abutments is 1,220 feet, and width 60 feet. It is like the other highway bridges on piles in bents averaging 12.4 feet between centers, minimum width 6.8 feet, maximum width 15.5 feet. The bridge rises from each abutment to the draw opening, which is 35 feet 10 inches, and spanned by a draw moved by steam power revolving around a vertical axis, leaving one opening only for the passage of vessels; steam capstans are provided to assist them. Two horse-railroad tracks occupy the roadway between sidewalks.

The piles of this bridge are driven in bents oblique to the axis of the bridge, and the bottom of the lowest stringer is near the ends 1.3 feet above mean high water, and at the draw 5 feet.

Above this bridge Charles River opens out into a basin, and shoals rapidly in the channel. The Boston front is walled and laid out as a park and gymnasium, it having been completely abandoned for commercial purposes. The opposite side (East Cambridge) presents extensive flats, covered only at high water. The flats are being filled in, and the site will no doubt be occupied by manufactories, and perhaps this front may eventually be used for wharf purposes, but at present the shoals are bare at low water. The front measures 3,000 feet along the proposed harbor-line between Craigie's and West Boston bridges.

WEST BOSTON BRIDGE.

This is similar in construction to the other highway bridges; it was built in 1792, is 2,044 feet long and 50 feet wide. It is level like the Charles River Bridge. The average width of bays is 16.6 feet, the minimum being 9 feet and the maximum 18.7 feet.

It has a double draw opening, one 35 feet 8 inches, the other 36 feet, with a swing bridge moved by steam about a vertical axis, and steam capstans to aid the passage of vessels. The bottom of the stringers is 3.16 feet above mean high water, the bottom of the draw 2 feet. It has two horse-railroad tracks and sidewalks.

Above this bridge lies the extensive Charles River Basin reaching to Cottage Farm, or the Brookline, and Grand Junction Railroad bridges, a distance of about 2 miles. It is crossed midway by the new Harvard Bridge (2,150 feet between abutments), a modern-built structure of iron supported on stone piers, slightly arched from end to end, giving 9 feet of head room above high tide through bays 105.58 and 75.42 feet wide.

The Boston side of this basin is walled and the borders devoted to residential purposes. The Cambridge side is proposed to be similarly occupied; about 2,000 feet of wall have already been built, and it is contemplated finally to lay out a park 200 feet wide along the whole front.

One or two coal wharves at Brookline Bridge on the Boston side represent the commerce of this basin on the right bank.

About 8 feet of water can be carried through the West Boston Bridge at low water. From a point just above this bridge the United States dredged a channel 7 feet deep to Western Avenue Bridge, a distance above the mouth of the river of 4¾ miles, and above Brookline Bridge 1 mile, and 2½ miles more to the Arsenal were improved to a depth of 6 feet in 1880–1884.

Along this narrow reach of the improved river bridges cross it in the following order: River Street, Western Avenue, Brighton Street, Arsenal Street, and near these bridges are landing places or wharves for coal, lumber, and other building materials.

This description of the river, for the purpose for which it is intended, will hardly be complete without a mention of the railroads traversing the region that formerly depended upon the river for its supply of coal and building material. Below the Watertown dam two railroads are close at hand: The Watertown branch of the Fitchburg on the north side, and the Boston and Albany main line on the south side with the Grand Junction branch crossing to the north side at Cottage Farm, and running down through Cambridge and Charlestown to East Boston. The Union freight railroad through Commercial and Atlantic avenues skirts the wharves of Boston proper and connects the northern and southern system of roads entering Boston.

Summary of bridges.

Name.	Year built.	Length between abutments.	Width.	Height of lowest timber above M. H. W.		Width of draw.	Width of bays.		
				At abutments.	At draw.		Least.	Greatest.	Average.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Ft. in.*	*Feet.*	*Feet.*	*Feet.*
Charles River Bridge	1785	1,102	50	0.60	1.4	36 0	5.0	25.0	15.9
Warren Bridge	1828	1,320	80	1.16	6.16	36 3	10.0	16.5	15.8
Craigie's Bridge	1808	1,220	60	1.30	5.0	35 10	6.8	15.5	12.4
West Boston Bridge	1792	2,044	50	3.66	2.0	35 8 36 0	9.0	18.7	16.6

TRAFFIC ON THE RIVER.

The following is a tabular statement of the number of vessels passing the Charles River bridges annually for a series of years:

Date.	Charles River Bridge.	Warren Bridge.	Craigie's Bridge.	West Boston Bridge.
1881	9,300	7,200	3,675	2,700
1882	8,800	6,540	3,350	2,150
1883	8,100	5,775	3,250	2,525
1884	7,400	5,600	3,200	2,500
1885	6,800	5,000	3,150	4,850
1886	7,600	5,800	3,600	4,325
1887	7,500	.....	.....	.....
1888	7,600	.....	.....	.....
1889	8,000	.....	.....	.....
Total	71,100	35,915	20,225	19,350
Annual average	7,900	5,985	3,370	3,225

The following is a comparative statement of the number of vessels with and without cargoes which passed the bridges annually during the two years, at five years' interval:

Vessels.	Charles River Bridge.		Craigie's Bridge.		West Boston Bridge.	
	1884.	1889.	1884.	1889.	1884.	1889.
Number without cargoes	4,854	1,336	1,962	2,133	No record.	2,542
Number with cargoes	2,625	2,709	1,356	1,624	No record	616
Total	7,479	8,045	3,318	3,757	.....	3,158

The ratio of the cargo-carrying to the non-cargo-carrying vessels varies at each bridge. It is greatest at the Craigie Bridge and least at the West Boston Bridge.

Authentic statistics show that the annual tonnage of the Charles River is 1,500,000 tons approximately, and that 150,000 tons only are delivered above the West Boston Bridge.

The number of vessels passing the bridges does not vary much from year to year; the slight increase in the number during the last two years may be ascribed to the supply of building materials for the new Harvard Bridge and for the embankment walls of the river basin.

The traffic over the bridge is given by Mr. Hyde, representing the street railroads; by Mr. Marvin, superintendent of the upper bridges for West Boston and Craigie's bridges, and Mr. Whiting, chairman of the board of police of Boston, for Charles River and Warren bridges, as follows (daily average of six to twelve days):

Bridges.	Cars.	Passengers in cars.	Foot passengers.	Teams.
Charles River	388	7,980	7,741	2,742
Warren	1,380	25,250	12,823	7,667
Craigie's	635	11,457	7,791	6,011
West Boston	1,560	31,535	3,590	2,917

The large number of teams using the Warren Bridge is accounted for by the fact that most of the freight business of the Fitchburg and Boston and Maine railroads, whose freight yards are on the Charlestown side of the river, must pass over this bridge, and the teaming over Craigie's Bridge is on account of the large number of manufacturing interests of East Cambridge and Cambridgeport.

LEGISLATION OF THE STATE CONCERNING THE DRAW-OPENINGS IN BRIDGES OVER CHARLES RIVER.

Previous to 1869 the opening of Charles River Bridge was about 36 feet in width and the openings in the other bridges were about 30 feet, the openings in the highway bridges being a little the widest.

By acts of 1869, chapters 272, 291, 311, 343, and 352, the legislature authorized the various railroads to widen their bridges across Charles River and Miller's River, and at the same time directed them, and also the owners of the highway bridges, to make the draw-openings through all the bridges of a uniform width of 44 feet.

In accordance with this legislation the draw in the Charles River Bridge was widened to 44 feet, and the Fitchburg Railroad Company had had its plans approved and had commenced work to widen the draw in its bridge to 44 feet.

By acts of 1870, chapters 300 to 303, the legislature directed that the width of the draw-openings through all these bridges should be 38 feet instead of 44 feet, and later in the session, chapter 401, directed that the width should be 36 feet instead of 38 feet.

By said chapter 301 the harbor commissioners and the railroad commissioners were constituted a board to confer with the railroads and the city of Boston, and report to the legislature a comprehensive plan for crossing the river, and other matters.

The report of the joint board of harbor and railroad commissioners, senate doc. No. 179, April, 1871, recommended reducing the number of railroad bridges to two and replacing Charles River and Warren bridges by one bridge, and enlarging and rebuilding Canal Bridge; all the bridges to be iron bridges, 100-foot spans resting on stone piers and abutments and having turn-table draws with double openings each 60 feet wide.

It also recommended the contraction of the river between Canal and Warren bridges to a general uniform width of about 900 feet, using the area of water encroachment so obtained for railroad terminal facilities in place of the bridges across the river, which were to be removed.

By acts of 1882, chapter 155, the legislature authorized the building of the Harvard Bridge, with a draw opening not less than 38 feet in width, the bridge to be built upon iron or stone piers and abutments.

By acts of 1885, chapter 129, the legislature amended the above, requiring that the draw shall not be less than 36 feet in width, but providing that, if the draws in the bridges below are widened, the draw in this bridge shall be widened to correspond.

By acts of 1873, chapter 357, the legislature authorized the railroads on the north side of Boston to make contracts with each other for exchanging land, re-arranging their roads, stations, and terminal grounds, etc. All changes in structures over tide-waters and all new structures to be subject to approval of harbor commissioners, etc.

By acts of 1873, chapter 292, the legislature authorized the Boston and Maine Railroad and others to make changes in their terminals, all work on tide-water to be subject to approval of harbor and land commissioners.

ACTION OF HARBOR AND LAND COMMISSIONERS.

The Board now invites attention to the fact that the Commonwealth of Massachusetts has since 1866 confided the care of its waters, fresh and tidal, so far as relates to the construction of wharves, bridges, etc., to a board of commissioners, who have reported annually to the Commonwealth upon all the structures which had been built or authorized to be built during the year. The present commission is known as the harbor and land commissioners, which was organized by chapter 263 of the acts of 1879, and is the consolidation, without change of duties, of two commissions previously organized under separate names. The harbor commissioners were organized by chapter 149, act of 1866, and their duties in part are defined as follows:

SEC. 2. The board of harbor commissioners shall have the general care and supervision of all the harbors and tide waters, and of all the flats and lands flowed thereby, within the Commonwealth, except the Back Bay lands, so called, in the city of Bos-

ton, in order to prevent and remove unauthorized encroachments and causes of every kind which are liable to interfere with the full navigation of such harbors, or in any way injure their channels, or cause any reduction of their tide waters, and in order to protect and develop the rights and property of the Commonwealth in said flats and lands. They may, from time to time, make such surveys, examinations, and observations as they may deem necessary in any harbor for said purpose, and employ for these purposes competent engineers, and also employ such clerical and other assistance as they may think necessary. They shall inquire as to the riparian rights of the owners of land on the northerly shore of South Boston, both as to the flats lying between said shore and the channel and the rights of navigation over the same; and to ascertain whether said rights can be extinguished or harmonized with rights claimed by the Commonwealth; to prepare a plan for the improvement of said flats, and report to the next legislature. They shall have an office in Boston, where the maps, charts, and plans connected with the harbors, records of all their doings, and all documents relating to their business shall be kept.

This commission has been and is composed of experienced men, thoroughly familiar with the subject of the Charles River bridges, and their views in regard to their efficiency and to their effects upon the navigation of the stream are entitled to the greatest consideration.

The board quotes from their annual reports to the Commonwealth as follows:

1870. –One of the most important subjects upon which the board advised legislation last winter was the widening and improvement in location of the draws in the bridges over Charles and Miller's rivers. The bridges over Charles River have long been a standing offense against all principles upon which structures in tide-water should be built. The rows of piles on which they rest are at every sort of angle with the line of current and greatly obstruct its flow. The draws which, if placed in line with the current and so with each other, would afford an unobstructed water-way, and be convenient for the passage of vessels, were really in line with nothing. The seriousness of these obstructions in their merely physical relations will be appreciated when it is considered that the Charles River Basin is one of the most important of those tidal reservoirs of Boston Harbor, which keep its channels of the requisite depth for a great port of commerce, and that the river where crossed by many of these bridges is the outlet of this reservoir.

The maintenance of this basin and the improvement of its outlet has for a long time been regarded as of vital importance to the harbor, and that importance is, if possible, increased with every step taken in the displacement of tide-water in Boston Harbor by the occupation of the South Boston flats. Moreover, the draws in these bridges were not wide enough to accommodate the increasing breadth of beam of vessels carrying the class of freights which were delivered above them. The case was a clear one for reform, and last winter a favorable opportunity was presented for doing something. The railroad companies were applicants for legislation for their benefit, among them the Boston and Maine Railroad Company, and the Fitchburg Railroad Company, for leave to increase the width of their bridges upon flats of the Commonwealth. Petitions to the legislature numerously and influentially signed were also presented for wider passage-ways for vessels. The board co-operated with the petitioners, and endeavored to connect legislation upon the subject in the interest of the public with the legislation sought for the railroads.

It presented a plan for an increased width and a proper alignment of the draws, favorable to navigation and the flow of the tide. A draw 55 feet in width was recommended, in order that a vessel of the largest breadth of beam passing over these waters might go through with the tug-boat by her side, and a wide water-way be secured for the tide. Without adopting this recommendation to its full extent, the legislature finally provided, in chapters 272, 291, 311, 343, and 352 of the acts of 1869, that the commissioners on Charles River and Warren bridges, the city of Cambridge, and all the railroad companies having bridges over Charles and Miller's rivers should "forthwith" make, in lieu of existing draws in their respective bridges over these waters, draws with a clear passage-way of 44 feet in width, in such position and of such form and construction as the harbor commissioners should determine.

1871.—In the early part of the past year the work was finished of building a new draw and widening the draw-way in the Charles River Bridge to the width of 44 feet. This was done in accordance with the legislation of the year 1869, which required all the draws in the bridges over Charles and Miller's rivers to be widened to 44 feet and placed in such position as the harbor commissioners should determine, the object being to secure an alignment of the widened passage-ways so that vessels might go through them in a straight instead of a zigzag course. The new draw works admirably. It causes a detention of travel of but about seven minutes for every vessel pass-

ing through under average conditions. Every expectation the new draw at this point was intended to meet has been fully and satisfactorily answered by the commissioners having charge of the work.

The Fitchburg Railroad Company entered promptly upon the work of widening the draw in its bridge, and only waited for the cessation of navigation in the winter whhich the construction of the draw would obstruct to comply fully with the requirements of the law. A renewal of the discussion of this question in the legislature led to still further delay.

The Boston and Maine, Eastern, and Lowell Railroad companies exerted themselves to secure a large reduction of the width prescribed by the statuste of 1869. All these railroad companies, as also the Fitchburg, had been applicants for the privilege of making extensive encroachments on the flats and water areas of Charles River, already excessively encumbered, and the duty of reconstructing their draws to the width of 44 feet in proper position was imposed upon them as a compensating benefit to the harbor and to navigation which they ought in fairness to perform. The Fitchburg Railroad Company began at once both to occupy its grants and to widen its draw to the required width. The other companies, having obtained the privileges they applied for, preferred to concentrate their energies upon securing a reduction to the lowest terms of the obligations imposed upon them, and succeeded in getting a law passed reducing to 38 feet the width of 44 feet that had been previously prescribed. At this stage of the proceedings the aldermen of the city of Boston for the first time intervened in their capacity, as they declared, of "surveyors of highways," and the opinion was expressed that the widening of the draw-way of Warren Bridge to 38 feet would involve the removal of the water-pipe across Charles River at a cost of $10,000, and that 36 feet was in their judgment a sufficient width as a passage-way for vessels. It was perhaps questionable whether the water-pipes of the city, or the passage-way for vessels on Charles River, although part of what is called the "highway of nations," were within the jurisdiction of the board of aldermen as surveyors of highways. The opinion too that width of 36 feet would be less of an interference with the water-pipe than 38 feet proved to be erroneous, and the water-pipe to be one not in use. This intervention, however, was the occasion for an attempt still further to reduce the width of the draw-ways, and in the last days of the session a bill was introduced and enacted requiring not merely the draw in Warren Bridge but all the draws that were to be reconstructed on Charles and Miller's rivers, ten in number, to be built 36 instead of 38 feet wide.

There is a satisfactory ground on which the reduction of the width first established for these draw-ways can be maintained, and the board are glad to believe it to have been the real one; that ground is the conviction that all these railroad bridges must in a short time be reconstructed or a new way devised for the railroads to cross Charles River that shall be less obstructive to navigation and injurious to the harbor of Boston, and therefore such temporary provision as can be made to answer the immediate demands of navigation until this radical reform takes place is deemed sufficient. An act passed by the same legislature that made these successive reductions in the width of the proposed draw-ways providing that the railroad and harbor commissioners should, if possible, submit to this legislature a comprehensive and feasible plan for improving, at the same time, the navigation of Charles River and the terminal facilities in Boston of the railroad entering the city on the northern side, indicates that such considerations had a controlling influence. Both boards, acting together as a joint commission, have given this subject a great deal of attention, and will submit their results to the legislature in a joint report.

[From the report of the joint commission, 1871.]

In place of the five railroad bridges, the commissioners propose to have only two, and instead of these resting upon piles driven haphazard, that the bridges shall be iron bridges, in spans of 100 feet, resting upon stone piers built in lines parallel with the thread of the stream. Furthermore, it is proposed that the draws shall be placed in the middle of the water-way, and that they shall be pivot or turn-table draws, with a passage-way 60 feet wide on each side, thus allowing double or treble the number of vessels to pass at one opening of the draw that are now accommodated. As a corollary to this improvement in the railroad bridges in behalf of navigation, it is proposed that there shall be but one bridge to Charleston instead of two, that this shall be 100 feet wide, and shall also have a turn-table draw, with an opening of 60 feet on each side. Craigie's Bridge should also be enlarged and provided with a similar draw. These two bridges should also be of iron, resting on stone piers, like the railroad bridges.

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In view of this great obstruction to the land travel, which is constantly increasing, and the comparatively small amount of navigation upon the river, the idea has been suggested that the time must soon come when the draws must be closed and no navi-

gation, except by lighters which could pass under the bridges, should be allowed. The present mayor of Cambridge in his address to the city council took the same view. Land transportation is continually gaining upon that by water; and perhaps a succeeding generation may be satisfied that it is cheaper and more convenient to have freight transported from wharves below all the bridges by the Grand Junction on the side of the river and a marginal railway on the south than to carry it by vessels through many draws. But at present such a course seems inexpedient; and as, moreover, to close the navigation of the river would require the consent of Congress, which would hardly be given as long as the United States retains its arsenal at Watertown, it is unnecessary to dwell upon that proposition. For the present generation the improved draws above suggested, allowing more vessels to pass at one opening, with a regulation also that the draws shall only be opened at night, say between 7 p. m. and 6 a. m., will probably afford all necessary accommodation both to navigation and to land travel. And if the number of vessels should increase materially, the employment of steam-tugs to quicken their passage through the draws should also be required by law.

[From Annual Report of the Harbor Commissioners.]

1872.—In determining the best plan for draw-way openings and draw-bridges for Charles River and Fort Point Channel many conflicting considerations must be adjusted; the main object in view being to provide such structures and determine such modes of operating them as shall offer the least obstruction and delay to both the water and land transit. As the passage of vessels through the bridges is a primary condition of the case, a draw-way opening which shall most facilitate their passage through it is a first consideration. This should be of such a width as to allow a tug and vessel to pass through without checking their general speed and without the liability of striking against the sides of the passage-way. Where the depth of the channel is not much more than the draught of the vessel, so that she would otherwise nearly fill up the passage-way some space should be allowed on either side of her for the relief of water flowage, particularly where strong currents are to be met. Spaces of 5 or 6 feet between each side of the vessel and the sides of the passage-way are not undue allowances.

As regards width of water-way, if the waters of Fort Point Channel and Charles River above the first bridge are to be used by vessels no larger than those which now use them, or are likely to use them while as obstructed as they now are by bridges, a width of 44 feet, which the legislature of 1869 prescribed for the draws in the Charles River bridges, would perhaps be sufficient for all the draws except that in the bridge between Charlestown and Boston, which should have a width of at least 60 feet in consideration of the extensive basin there will be between the Fitchburg Railroad Bridge and the bridge which it is proposed shall be substituted in place of Charles River and Warren bridges.

* * * * * *

The expediency of a new bridge between Boston and Charlestown, in place of the Charles River and Warren bridges, is a question which has been much discussed, and belongs to the subject under consideration. Not that the reduction of the number of draws to be opened to one is of itself to give any relief, for, as the amount of travel on both bridges would be concentrated on one, the same amount of travel would be delayed by the opening of one draw that was before delayed by the opening of two. But the draws now in use in these bridges are retractile draws, and not of that model that insures the least detention of travel. The characteristics of the true model for a draw have been already discussed. And this model has been found in the center pivot draw, with double openings when practicable, an easy width of water-way, and a roadway on the draw itself of the least practicable width that shall accommodate the travel.

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The measures then that seem the best to secure the relief of traffic over Charles River and Fort Point Channel are as follows:

* * * * * *

Fourth. The adoption of center-pivot draws, which, when practicable, shall have double openings, and to secure lightness of weight and rapid movement shall have the least possible width which shall relieve the accumulation of teams caused by the passage of vessels without adding to the delays of the land transit.

* * * * * *

Eighth. The substitution of one first-class bridge between Charlestown and Boston in place of the present Charles River and Warren bridges.

1873.—An excellent new draw in Warren Bridge, with a new passage way 36 feet wide, has been constructed by the commissioners on the Charles River and Warren

bridges during the past year. It is operated by steam-power, with great facility and dispatch, and is unquestionably one of the best draws in the neighborhood of Boston.

Plans for new draws and passage-ways 36 feet wide in the passenger bridges of the Eastern and Boston and Lowell Railroads over Charles River, and in the Eastern and Boston and Maine Railroads over Miller's River have been approved by the board.

1875.—When the question of widening the draw-way openings in the Charles River bridges was before the legislature, in its session of 1869, so as to have them conform to the increased size and width of modern vessels, the board made a very careful study of the subject. The location and alignment of the bridges, the outlines of the channel, and the complicated currents which struggle through them were made a matter of thorough investigation. With a system of new and wider draws, the question of the location of the draw in each particular bridge was carefully considered.

As the result of this study the present plan of a straight pathway through the bridges was devised, as giving the best facilities for the rapid and convenient passage of vessels through them and causing the least detention to the railroad, wagon. and foot-passenger transit over the railroad and city bridges which the case admitted. In the interest of the railroad transit over the bridges, this line of the passage-way was thrown as far towards the center of the river and from the Boston shore as the character of the channel and the existence of shoal ground along its northern margin would admit, so as to give the greatest distance practicable between the depots of the various railroads on the Boston side and the draws.

1883.—The location and character of the numerous bridges which encumber the mouth and throat of Charles River have always been considered as objectionable, and every well devised scheme of harbor improvement has pointed to the correction of these injurious structures as a *sine qua non* to the restoration of this channel to its fullest physical and commercial capabilities. So familiar are the facts and arguments bearing upon this subject, that it is unnecessary to repeat them here. With the largest latitude in favor of artificial methods of improvement, the peculiar configuration of Boston Harbor, with its succession of straits and basins, gives peculiar value to its natural tidal forces. The constantly recurring change of 10 feet in the ocean level and the power of its influences are elements of security on the one hand, and of danger on the other, which no proper consideration of the conservation of the harbor can ignore.

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There had been no physical survey of the Charles River for more than twenty years. The board deemed it necessary, therefore, to make a re-examination and survey of this part of the harbor, in order to ascertain, if possible, by its results, how, and how much, if any, the water space of the Charles River may be encroached upon by solid or pile structures without injury to the present facilities of navigation.

The peculiar configuration of Boston Harbor, as before remarked, and the pressure of the large tide into its arms and reservoirs, make it manifest that these facilities may be improved by reducing the width and depth of channels; by augmenting the rush of water through the bridge-draws, which are the only means of access to the upper basins; or by producing unequal scour, and thereby creating excessive excavations in one place and obstructive shoaling in another.

1885.—While the Commonwealth is devising wise and liberal measures for the preservation and improvement of this important harbor, and the United States is appropriating and expending large sums for the same purpose (about $1,700,000 in the last twenty years), it needs no argument that artificial works and structures which tend to its injury ought to be carefully avoided. Oftener from a want of knowledge or appreciation of the evil effects likely to result than from wrong intent, and in the haste to secure some present end suggested by private interest or the seeming demand of municipal economy or convenience, the broader public interest is forgotten, and it becomes difficult to resist measures which are wholly indefensible in the light of well-established principles of harbor conservation. The city of Boston in this way at times becomes, by the misdirected zeal of its officials, the most formidable enemy to its own harbor.

In reviewing the acts of Congress, July 5, 1884, and August 11, 1888, relating to bridges across navigable waters of the United States, the harbor commissioners of Massachusetts in their annual report for 1889, say:

Several points may be noted in respect to the foregoing legislation:

(1) It applies only to bridges across navigable water-ways of the United States, and not to any other structure or work in or over navigable waters.

(2) It provides only for the alteration of bridges, and does not contemplate their abatement or removal except as the bridge owner may choose to remove rather than to alter as required.

(3) The act of 1884, section 8, applies only to cases of obstruction by reason of difficulty in passing the draw-opening or raft-span of a bridge, and provides for auxiliary

structures for guiding the passage of water-craft through the same, but not for the alteration of the bridge itself.

(4) The act of 1888, sections 9 and 10, is much broader and applies not only to the cases just named, but to cases of obstruction "by reason of insufficient height, width of span, or otherwise," and provides for such alterations of the bridge itself as shall "render navigation through or under it free, easy, and unobstructed."

(5) The act of 1884 expressly provides that the order of the Secretary of War shall specify the "suitable and proper" structures to be built as aids in guiding water-craft through the draw or span. The act of 1888 provides that the Secretary shall prescribe the time within which the required alterations of the bridge must be made, but does not in express terms direct him to specify how they shall be made. A reasonable construction of section 9 would seem, however, to require such specification, either in the original order or as supplementary thereto. Before issuing the order the Secretary must find that the bridge is an obstruction to navigation, not merely as a bridge, but by reason of particular defects or insufficiencies of plan or construction which admit of remedy by alteration. It then becomes his duty to order the owner of the bridge to alter it so as, that is, in such manner as to render navigation "free, easy, and unobstructed." It can not be the intent of the statute to leave the manner of alteration to the discretion of the bridge owner, or to compel him to proceed in the dark and at his peril in respect to what he is or may be required to do. There is no uniform rule or standard of bridge construction fixed by law or precedent to which, in the absence of specific directions, he can refer. The intent must clearly be that the same officer of the Government who is empowered to adjudge that the defect exists shall determine and prescribe the method of cure. It would seem, therefore, that an order under the statute is incomplete until it has specified the required alterations with such detail as to leave to the party on whom it is served only the duty or question of specific performance.

(6) Without specially noting other provisions of these novel and interesting enactments it is important to observe that they do not purport to take away or narrow the concurrent power heretofore existing in the several States to authorize the construction of bridges across navigable waters. The act of 1884, section 8, distinctly recognizes this power, and the provisions of both acts apply alike to bridges "now or hereafter to be constructed over any of the navigable waters of the United States, under authority of the United States or of any State or Territory." Grants for such bridges, whether past or future, and whether under national or State authority, must now be understood to be qualified by such right of alteration as the statutes in question confer—a right which, if always within the province of Congress to assert, has not until now been exercised. Except to this extent, these statutes do not appear to touch in any manner the existing system of laws in this Commonwealth relating to navigable waters, or to affect any of the powers and duties of this board in respect thereto. In prescribing plans for the erection and alteration of bridges the advice of the able engineers of the War Department in charge of the rivers and harbors of Massachusetts has always been freely sought and courteously given, and it is not believed that any collision of opinion or authority is likely to occur.

Such are the views of the State commissioners officially addressed to the State, and the Board has quoted at length from their several annual reports to show that the bridge question of the Charles River has been presented repeatedly since 1866 to the legislature of the State by its own appointed conservators for harbors and rivers, and the city of Boston has been constantly reminded by these reports of the degree in which the bridge system maintained by its authority across that river within the city limits affected the navigation of that portion of the harbor which lies adjacent to the mouth of the Charles River.

Further, the commissioners have repeatedly stated, as shown by the foregoing quotations from their reports, that the draws in the city bridges were not wide enough for the convenience of shipping, and recommended in 1870 that the bridges be arranged with double draws giving 60 feet on either side of a central pivot. For reasons unknown to the Board these recommendations were not adopted by the legislature, and the draws are to-day what they were in 1870, single draws in general with a narrow width of 36 feet only.

The conditions affecting the navigable requirements of the river have not changed, however, except that the Charles River has shoaled greatly at its mouth, although not sufficiently as yet to obstruct navigation,

and extensive encroachments have been made upon the Charles River basin.

The Charles River where it traverses the city still remains an important tidal reservoir and a valuable highway for commerce, which the General Government should not only unceasingly protect against wanton injury, but foster by increased facilities where such can be secured with a consistent regard to vested rights.

RECOMMENDATIONS.

The Board at the outset finds itself embarrassed in giving that broad consideration to this subject which the interests of the public demand, (1) by the language of the statute which restricts the application of the punitive clause by which the action of the Secretary of War is to be enforced to bridges considered obstructions to free navigation by reason of "insufficient height, width of span, or otherwise," or where there is "difficulty in passing the draw opening by water-craft; and (2) by the limitation of the scope of its inquiries to those bridges which are owned or controlled by the cities of Boston and Cambridge.

The fact that the forest of piles which now constitutes the supports of the nine lower bridges across Charles River are detrimental to the value of Charles River Basin as a tidal reservoir for the preservation of the harbor has been recognized by all the numerous boards composed of United States and State officers who have considered the subject; but this aspect of the question, although vitally affecting the interests of navigation, appears to be excluded by the terms of the statute.

It must also be urged with emphasis that all the bridges across the Charles River from Charles River Bridge to West Boston Bridge both inclusive, highway as well as railroad, form a connected and single system, the several members of which are so intimately related that commerce can derive no practicable benefit from a modification of one bridge unless a corresponding change be made in all; and that the difficulties in the way of correcting defects in the railroad bridges are so much greater than for the city bridges that the former must govern in determining what can reasonably be required.

Proceeding to details, it is apparent from the tabular statement of the heights of the bridges that there is no such thing as navigation "under" any of the bridges considered, even if the restricted widths of 5 to 25 feet between the bents or points of support admitted of the passage of vessels. The navigation of the river (The State of Pennsylvania *vs.* The Wheeling and Belmont Bridge Company, Supreme Court Decision, Parke, page 162) is therefore obstructed and can not be called "free." The obstruction is limited, however, as the bridges all have draws for the passage of vessels, and they are therefore not "nuisances." It remains then to determine first whether the draws are of ample size for the vessels which demand to go beyond them, and second, whether they are maneuvered by proper appliances for speedy opening and closing.

The Board is of the opinion that for the present the draw openings through the West Boston and Craigie's (Canal) bridges, although small, may be retained without material injury to commerce, but that the openings through Charles River and Warren bridges, now 36 feet wide, ought to be enlarged whenever the renewal of the bridges is taken in hand, to make the navigation through them "free, easy, and unobstructed" for vessels exceeding about 700 tons. The Board was furnished by bridge-tenders with the names of several vessels which had

applied to pass the bridges, but could not be so accommodated because their beams exceeded the width of the draw, and it is fair to presume that the known deficient width of the draw prevented applications from being made by other vessels.

The draw-bridges, although of primitive type, are maneuvered by steam power with good appliances, and the time consumed in closing and opening the draws is not so great as to detain vessels unnecessarily for this reason alone.

The basin between the Charles River and Warren bridges is so limted in area that only seven to nine vessels can conveniently anchor there at one time. The only other possible anchorage, so long as the present bridge system is maintained, lies above the last railroad bridge. Therefore it may be said in general that there is no object in a vessel bound to the upper basin endeavoring to go above the Charles River Bridge unless facilities be given for its passing the entire bridge system. In practice vessels lie at anchor below Charles River Bridge, and pass through and above it in numbers corresponding with the opportunities afforded for going beyond the railroad bridges.

For these reasons while the Board is of the opinion that the draws of the Charles River and Warren bridges are not adequately wide for the largest class of vessels which may navigate the river, and that in the case of all the city bridges the flow of the water is excessively and needlessly obstructed, it does not recommend, in the absence of specific instructions as to the modifications to be made in the railroad bridges, that the city be required to incur at this time expenses for alterations in the bridges controlled by them, which might not conform to the alterations hereafter to be demanded from the railroad authorities. It is, however, recommended that when extensive repairs or rebuilding of these old city bridges become necessary they shall be made to conform to modern practice, as has been done in the case of the new Harvard Bridge just completed. Such a requirement would be far less onerous than the plans outlined above proposed by the joint commission composed of the harbor commissioners and railroad commissioners, to which the subject was referred for report by the legislature of Massachusetts in 1870.

Respectfully submitted.

HENRY L. ABBOT,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.
G. L. GILLESPIE,
Lieut. Colonel of Engineers.
S. M. MANSFIELD,
Lieut. Colonel of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
February 11, 1890.

Respectfully submitted to the Secretary of War.

The Board of Engineers constituted December 14, 1889, by authority of the Secretary of War, to consider bridges across Charles River owned or controlled by the cities of Boston and Cambridge submits the within report, dated February 1, 1890.

The Board is of the opinion that for the present the draw-openings

through the West Boston and Craigie's (Canal) bridges, although small, may be retained without material injury to commerce, but that the openings through Charles River and Warren bridges, now 36 feet wide, ought to be enlarged whenever the renewal of the bridges is taken in hand to make the navigation through them free, easy and unobstructed for vessels exceeding about 700 tons.

While the Board is of the opinion that the draws of the Charles River and Warren bridges are not adequately wide for the largest class of vessels which may navigate the river, and that in the case of all the city bridges the flow of the water is excessively and needlessly obstructed, it does not recommend, in the absence of specific instructions as to the modifications to be made in the railroad bridges, that the city be required to incur at this time expenses for alterations in the bridges controlled by them which might not conform to the alterations hereafter to be demanded from the railroad authorities.

It however recommends that when extensive repairs or rebuilding of these old city bridges become necessary they shall be made to conform to modern practice, as has been done in the case of the new Harvard Bridge, just completed.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

[Second indorsement.]

WAR DEPARTMENT,
February 27, 1890.

The views expressed by the Board of Engineers, constituted December 14, 1889, and the indorsement of the Chief of Engineers upon the same of February 11, 1890, are concurred in and approved by me.

The time fixed in the orders of the Secretary of War of December 6, 1888, requiring the cities of Boston and Cambridge to renew their bridges by the first of January, 1891, is hereby indefinitely extended, subject to further action whenever the conditions suggested by the Board require it.

REDFIELD PROCTOR,
Secretary of War.

Y Y 7.

REPORT OF BOARD OF ENGINEERS ON ALLEGED OBSTRUCTION OF NAVIGATION BY CERTAIN BRIDGES OVER HARLEM RIVER, NEW YORK.

NEW YORK CITY,
June 19, 1890.

GENERAL: The Board of Engineers, convened by Special Orders No. 25, Headquarters Corps of Engineers, dated May 7, 1890, to investigate and report upon the alleged obstructions of navigation by certain bridges over the Harlem River, New York, has the honor to submit the following report:

A public meeting was called on May 15, at which all the interests involved were represented. After the object of the hearing and the instructions of the Board had been stated, a proposition for an adjournment was made by the counsel of the New York Central and Hudson River Railroad, upon the ground that action is now pending in Congress on the river and harbor bill, which contains provisions bearing upon the

complaints now brought against the bridges, and which may prove satisfactory to the interested parties; also, that if this bill shall become a law, a specific act will govern in this case, rendering action under the general law of 1888 unnecessary. This proposition was concurred in by the counsel for both complainants, who stated that the pending law is satisfactory to the interests they represent. The counsel for the city stated that he had no objection to the proposed adjournment, and there being no opposition thereto, the Board adjourned, to report the facts and to request further instructions.

Upon the receipt of your instructions of May 17, disapproving the application of the parties in interest that the hearing be postponed, another public meeting was called for May 26, at which all the parties interested were present or represented by counsel. The hearing was continued on May 31 and June 3, and every effort was made by advertisement and by addressing circular letters of invitation to individuals known to be informed on the subject to obtain the attendance and views of persons familiar with the matters at issue. The stenographic record of these hearings is appended, marked "A."

The following documents* from the parties named have been received and are transmitted as appendices to this report, viz:

B. Proposition of land-owners and those interested in navigation on the Harlem.

C. Protest of land-owners near Park avenue to the raising of the grade of the railroad.

D. Memorandum brief on behalf of the city on the legal interpretation of the United States bridge law of 1888.

E. Reply to said brief by land-owners and those interested in navigation on the Harlem.

F. Reply to said brief by the New York City and Northern Railroad.

G. Letter from counsel of the New York Central Railroad stating that the State act authorizing the raising of grade has failed to become a law, and inviting attention to the resulting consequences.

H. Eight affidavits filed by the corporation counsel of New York City relative to navigation of Harlem River.

I. Map of the site of the two bridges in question, from a recent survey made under direction of Colonel Gillespie. A full description of these bridges is contained in Colonel Gillespie's report, dated April 5, 1890, herewith.

K. Letter from Mr. A. H. Green, dated June 20, 1890, holding that present bridges are obstructions to navigation.

These papers, together with the records of the preliminary hearing before Colonel Gillespie, herewith, and of the first meeting of this Board, transmitted on May 16, complete, the documents in the case.

From these documents it will be noted that five different interests have been represented, viz:

(1) The New York City and Northern Railroad, represented by Sherman Evarts, esq; their freight is shipped to and from their city station on One hundred and Fifty-fifth street and Harlem River on floats *via* the Harlem River from and to East River.

(2) Land-owners and others interested in the navigation of the Harlem, represented by Fordham Morris, esq.

Both of these complainants urge that the Fourth Avenue Railroad Bridge and the Third Avenue Highway Bridge are now obstructions to the navigation of the river, and that they will become still more so when the Harlem River improvement, upon which large private investments are now based, is completed by the Government.

(3) The New York Central and Hudson River Railroad, which controls and operates the Fourth Avenue Bridge, represented by Frank Loomis, esq., and by Colonel Katte, chief engineer. The company ad-

* Not printed.

mits that its bridge should be modified by placing the piers parallel with the current, and this it proposes to do when remodelling the structure to receive four tracks, a change now demanded by the increased traffic crossing the Harlem. It claims that no raising of the bridge is necessary, and that no change of grade is possible without a special act of the legislature, that matter being regulated by State law.

(4) The city of New York, owning and operating the Third Avenue Bridge, and represented by Edward H. Hawke, jr., esq., assistant corporation counsel. The city claims that its bridge is not an obstruction to the existing commerce of the Harlem, and presents a brief arguing that under the river and Harbor act of 1888 no legal penalties can be enforced against a prospective obstruction.

(5) Certain land-owners and others near Park (Fourth) avenue, north of One hundred and twenty-fifth street, who object to any raising of the grade of the railroad that will interrupt free passage across it between One hundred and twenty-fifth street and One hundred and thirty-second street. They were represented by Col. George P. Webster.

The peculiar conditions affecting the navigation of the Harlem deserve attention, since they define the character of the bridges which should be allowed to cross the river.

At present there is no through navigation between North River and East River by this route, but, nevertheless, there is a very large local commerce along the banks from High Bridge to the mouth of the Harlem, estimated for the fiscal year 1889–'90 at 3,384,466 tons and valued at $115,506,425. This now consists in part of building materials required to meet the demands for new constructions in the upper part of Manhattan Island and prospectively in the annexed district; but there are also local manufactures of no slight importance. Moreover, by the co-operation of the General Government and the State authorities, an improved water-way connecting North and East rivers has been projected and is now in process of construction, following mainly the bed of the Harlem. So soon as through navigation is achieved, the new route will afford a passage for vessels drawing 15 feet at mean low water, and will thus not only open new facilities for local commerce, but will also afford relief to the crowded water-fronts of the lower parts of the island.

On the other hand, the immense and increasing demand for free transit between Manhattan Island and the country to the northward can not be ignored. At present 242 scheduled trains cross the Harlem daily and the highway bridges are thronged with vehicles and foot passengers, especially during the early morning and evening hours. Indeed it was the pressure of this transverse traffic exerted to restrict the hours when the draws may be opened that probably led to the present complaint against the bridges.

Clearly some compromise is needful between these great and conflicting interests. In the opinion of the Board this can best be effected by insisting that all the bridges shall afford a free water-way of not less than 100 feet in width and a free headway of not less than 24 feet at extreme high water. The testimony before the Board indicates that from two-thirds to three-quarters of the present traffic is carried on in floats, barges, canal-boats, and other craft which can pass under such spans when towed by tugs with hinged smoke-stacks, like those in general use in Chicago, without requiring the draws to be opened. With large navigation thus rendered free and untrammeled at all times, great relief will be furnished both to commerce on the river and to travel crossing it.

Considerations of this character probably led to the enactment by the State legislature in 1879 of the statute which now regulates the construction of all new bridges over the Harlem. The conditions to be fulfilled are the following:

Provided, however, That the direction of the bridges hereafter to be constructed over said river or creek shall be at right angles to the courses of the improved channel; that the height of the bridges in the clear at the draws shall be not less than 24 feet above the high water of spring tides, and that the number and size of the bridge piers within the improved channel shall first be approved by the engineer of the United States in charge: *And provided further*, That no tunnel shall be constructed under said river or creek which will not permit of the excavation of a channel above it of at least 20 feet in depth at mean low water. There shall be constructed in every bridge, except in suspension bridges, hereafter built over said river or creek, two draws contiguous to each other, and the length on the bridge occupied by the draw-spans and the center pier separating them shall be at least 240 feet.

These conditions are essentially fulfilled by all bridges crossing the navigable part of the Harlem, except by the two which form the subject of this complaint and by the Central Avenue Bridge, which latter is to be rebuilt in accordance therewith under a State act dated April 29, 1890.

After carefully weighing the conflicting testimony and examining the bridges themselves, the Board is of opinion that, although both of them are provided with steam draws, admitting of rapid service, and although both appear to be well served, nevertheless these bridges are obstructions to the free navigation of "a navigable waterway of the United States" "by reason of insufficient height and insufficient width of span," in the sense in which the words are used in section 9 and section 10 of the river and harbor act of 1888; and the Board is further of opinion that they should be made to conform as nearly as may be to the requirements of the State legislation for new bridges over the Harlem, quoted above.

In the case of the Third Avenue Bridge this will require the clear headway to be increased from approximately 12 feet to 24 feet above the level of high water of spring tides, and each of the draw openings from approximately 80 feet to 100 feet in the clear; suitable guiding fenders should be supplied.

In the case of the Fourth Avenue Bridge the clear headway would be increased from approximately 6 feet to 24 feet above the level of high water of spring tides. At this bridge it is difficult to conform to the conditions that its direction "shall be at right angles to the course of the improved channel," and therefore the present direction may be retained, but if so it is recommended that the clear openings of the double draw be widened accordingly, so that their minimum width measured on a line perpendicular to the direction of the improved channel at the site shall be not less than 100 feet, and that the piers shall be parallel to the current and be furnished with proper guiding fenders. In respect to this bridge it is also to be noted that the extensive changes now contemplated, by which it is to be doubled in capacity and approximately so in width, are in effect a reconstruction, and for this reason it could now be more easily made to conform to the State law above quoted, applicable to new bridges. The objections to the raising of the grade of One hundred and twenty-fifth street seem to the Board to to have been exaggerated. It is possible to begin the change at One hundred and twenty-seventh street without exceeding the grade now in use between Fifty-first street and Fifty-seventh street. Indeed, it may be said that there are no engineering difficulties which can not be readily overcome. To change the railroad grades from One hundred

and twenty-fifth street to the bridge would, according to the testimony before the Board, injure the neighboring property, but the injury would probably be reduced if the change in grade only began at One hundred and twenty-seventh street.

As to what should be regarded as a reasonable time within which to complete the changes recommended, the Board is of opinion that so far as engineering questions are concerned a year and a half is an ample allowance. As to legislative difficulties in the way of making the changes within this time, the Board has no opinion to express.

Respectfully submitted.

HENRY L. ABBOT,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.
C. B. COMSTOCK,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.
G. L. GILLESPIE,
Lieut. Col. of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

APPENDIX Z Z.

OCCUPANCY OF AND INJURY TO PUBLIC WORKS BY CORPORATIONS AND INDIVIDUALS.

[Reported under section 2, river and harbor act of 1884, and section 4, river and harbor act of 1886.]

1. Report of Lieut. Col. G. L. Gillespie, Corps of Engineers.
2. Report of Capt. Thos. L. Casey, Corps of Engineers.
3. Report of Col. Wm. P. Craighill, Corps of Engineers.
4. Report of Capt. H. S. Taber, Corps of Engineers.
5. Report of Maj. James B. Quinn, Corps of Engineers.
6. Report of Maj. Chas. E. L. B. Davis, Corps of Engineers.
7. Report of Capt. W. L. Marshall, Corps of Engineers.
8. Report of Col. O. M. Poe, Corps of Engineers.

(1) REPORT OF LIEUTENANT-COLONEL G. L. GILLESPIE, CORPS OF ENGINEERS.

ENGINEER OFFICE, U. S. ARMY,
New York, N. Y., July 10, 1890.

GENERAL: In compliance with General Orders, No. 9, Headquarters Corps of Engineers, June 26, 1888, I have the honor to transmit herewith report on the subject of "piers, breakwaters, locks, and dams or other structures built by the United States, occupied or injured by corporations or individuals," river and harbor act August 5, 1886.

Very respectfully, your obedient servant,

G. L. GILLESPIE,
Lieut. Col. of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

The only instances of piers or other structures built by the United States which are occupied by corporations or individuals, referred to in the act of August 5, 1886, are found in the upper Hudson River. Some of the piers so occupied have been given in previous reports, but it is deemed best to recapitulate them, with the names of such additional piers as have been heretofore omitted.

(1) *Miller & Witbeck* have built a dock over 273 feet of the *half-dike at Mull's Island*, on the east side of the river, about 13 miles below the railroad bridge at Albany. The dike just above the dock has been heavily loaded with stone to serve as an ice-breaker, and shows signs

of giving way under the weight imposed upon it. This occupation of the dike was authorized by the honorable Secretary of War November 9, 1880, under an opinion of the Judge Advocate-General of the Army.

(2) *H. Slingerland* has built a dock over 103 feet of the *Barren Island Dike* opposite Coeymans, on the west side of the river, about 12½ miles below the railroad bridge at Albany. It is not known under what authority this was done.

(3) *The Knickerbocker Ice Company* occupy with their wharf 319 feet of the *Roah Hook Dike* on the west side of the Hudson River about 12 miles below the railroad bridge at Albany, by authority of the Chief of Engineers, under the opinion of the Judge Advocate-General of the Army before referred to, October 12, 1880.

(4) *F. E. Bean, now Ridgewood Ice Company*, uses for a dock 259 feet of the *Castleton Dike*, on the east side of the river, about 9 miles below the Albany Railroad Bridge. The dike is much broken for about 20 feet above the upper end of the dock. This occupancy is under authority of a grant of land under water by the State of New York, over which this United States dike is built.

(5) *E. T. Stimson, now Montauk Ice Company*, occupies for dock purposes 280 feet of the *Castleton Dike* about 400 yards above the part occupied by F. E. Bean, under approval of the Chief of Engineers dated September 11, 1871. The dock is being very little used, and has fallen into decay.

(6) *The Ridgewood Ice Company* occupy the lower end of *Cedar Hill Dike* on the west side of the river opposite Castleton, about 8½ miles below the railroad bridge at Albany, under authority of a grant of land under water made by the State of New York, upon which this dike is built.

(7) *The Sunny Side Ice Company* occupy for dock purposes a part of the dike in front of *Cow Island* on the east side of the river about 7½ miles below the railroad bridge at Albany, under what authority is not known.

(8) *Richard English, now George N. Best* occupies 258 feet of the *Campbell Island Dike* on the east side of the river, about 7½ miles below the railroad bridge at Albany, under authority of a grant of land under water by the State of New York, this dike being built over that land.

(9) *Whitehead Brothers* occupy for dock purposes about 25 feet of the *Cedar Hill Dike* on the west side of the Hudson River about 6 miles below the railroad bridge at Albany, under authority of the honorable Secretary of War, dated May 16, 1887.

(10) *Tillie and Littlefield* occupy 445 feet of *Winnie's Dike*, and 56 feet of *Bear Island single-pile dike* for an ice-house dock, about 6 miles below railroad bridge at Albany, under what authority is not known.

(11) *Hotaling & Park, now Knickerbocker Ice Company*, occupy 281 feet of the *Beacon Island revetment* for dock purposes, both dock and dike being in a very poor condition. Under what authority this dike was occupied is not known.

(12) *John Patterson* has built a dock 100 feet long over the old *revetment at Beacon Island*, on the west side of the Hudson River about 600 yards above Hotaling & Park's ice-house, under approval of the Chief of Engineers, dated December 16, 1881.

(13) *Race Course Dock at Cabbage Island.*—This dock occupies 73 feet of the *Overslaugh Dike*; the ownership and authority under which it was built are not known. Dock and dike are in good condition, and the dock encroaches 18 feet upon the bulkhead line, established March, 1890.

(14) *Clark & Lawrence* have built on Bogart's Island on the west side of the river, an ice-house dock, and occupy about 157 feet of *Bogart Island Dike*, 2½ miles below Albany. The dock is in good condition and has improved the frontage.

(15) *Schifferdecker Brothers* have cut 30 feet out of *Small Island Dike* at Albany, on the west shore of the river, to admit ice-boats to their ice-house behind that dike. This was done under authority from the Hon. Secretary of War, dated November 20, 1889.

(16) *Paul S. Forbes* has built a dock over 75 feet of the *Bath Dike* on the east side of the river about 1½ miles above the lower railroad bridge at Albany, under agreement and bond transmitted to the Chief of Engineers October 26, 1876. The dock has not been kept in repair, and the dike has given away under it.

(17) *W. H. Forbes* has extended the dock built by Paul S. Forbes about 225 feet farther north over the *Bath Dike*, under permit from the Hon. Secretary of War, dated June 15, 1882.

(18) *George Mark and others* have built a dock over the *old revetment of Patroon's Island*, on the west side of the river, about 2½ miles above the lower railroad bridge at Albany, extending out into the river 60 feet beyond the mean high water line, but not encroaching upon the bulkhead lines established in March, 1890. This dock was built without any authority other than that derived from the old colonial grant to the Patroon.

(19) *Erastus Corning* has occupied for dock purposes 105 feet of *High Dike* between Hillhouse and Patroon's Islands on the west side of the river about 3¼ miles above the lower railroad bridge at Albany, under authority of the Hon. Secretary of War, dated June 15, 1882.

(20) *The Troy Steel and Iron Company* (formerly the Rensselaer Steel and Iron Company) have built a dock over the *Port Schuyler Dike* 570 feet long, projecting into the river about 30 feet on one end and 50 feet on the other beyond the bulkhead line established in March, 1890; and also a bulkhead protecting their ferry slips below that dock, projecting 22 feet beyond the bulkhead line and covering Port Schuyler Dike for a distance of 150 feet, approximately. They have also cut through the dike about 50 feet to admit a ferry slip for their boats connecting their establishments on the east and the west shores of the river. This work is about 4½ miles above the lower railroad bridge at Albany, and all of it was built under authority of a grant of land under water by the State of New York.

It will be noticed that some of these docks project beyond the harbor lines established by the Secretary of War March 25, 1890, and in regard to such piers it may be stated that the Harbor Line Board did not intend by its recommendations to require existing structures to be interfered with, but only that such structures should be repaired within the recommended lines, so that in time the docks would be brought to the lines which better protected the navigation of the river.

STONE DIKE CONNECTING GREAT AND LITTLE MILL ROCKS, EAST RIVER AND HELL GATE, NEW YORK.

This dike was erected by the United States to aid in the operations for the removal of Flood Rock, Hell Gate, and was used for the storage of material and for wharfage for vessels connected with the works of improvement. After its erection it was claimed together with Great and Little Mill Rock by Mr. C. C. Higgins by notice of a grant to him

from the State of New York of the rocks and the land under water surrounding them.

The case was tried before the United States court, New York City, in 1888, and was decided in favor of the United States May, 1889. It is understood that an appeal from the decision has been taken.

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(2) REPORT OF CAPTAIN THOMAS L. CASEY, CORPS OF ENGINEERS.

Passaic River.—Dike in Newark Bay, N. J.—A full history of the unauthorized occupation of the training-dike in Newark Bay by the Messrs. Shanley, contractors for the New York and Waverly Railroad Company, is given in my annual report for 1890, page 850, to which attention is respectfully invited. A conditional and revokable license was finally granted, enabling the contractors to proceed with their work, and I was ordered at the same time to inspect the work at frequent intervals. No additional injury has been done.

Respectfully submitted.

THOS. L. CASEY,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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(3) REPORT OF COLONEL WILLIAM P. CRAIGHILL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., July 23, 1890.

GENERAL: Since the date of my letter of July 1, 1890, written in compliance with General Orders, Nos. 6 and 7, series of 1887, and 9 of 1888, from Headquarters Corps of Engineers, certain information has been received covering the ice-piers near the mouth of the Great Kanawha River, which is submitted below.

Complaint was made by Mr. John Armstrong, of Point Pleasant, that the Kanawha and Ohio Railway (now the Kanawha and Michigan), or their lessees, were filling up the river at or near the right shore below the Government ice-pier at Point Pleasant in connection with the operation of a "tie hoist" on the railroad company's land.

The lower ice-pier on that side is opposite lower line of the railroad company's land. The company own the land from this up to and for some distance above the upper ice-pier.

Assistant Engineer Scott went to see the situation on the 12th ultimo and reports as follows:

This tie hoist has been in operation but a few months, but there was already considerable material, such as raft strappings, bark and sunken ties close along the shore and in the edges of the water. No material change has been yet effected, but it is evident that unless considerable pains is taken to take care of this refuse the depth along the shore, both at the hoist and for some distance below, will be materially reduced by the operation of it.

It can in no case affect the navigation of the river. It may, however, and Mr. Armstrong claims it will, reduce the depth along the shore enough to interfere with the usefulness of the ice-harbor.

I have recently talked with the receiver of the railroad company, Mr. Robert W. Kelley, about the matter. He says it is the purpose of the company to attend to

this—to keep the tie refuse out of the river and not to let their landing or front get filled up by it. It is plain, however, that up to this time it has not been attended to properly.

It appears from the papers forwarded to you from Washington with the letter of May 31, 1890, from the office of the Chief of Engineers, that the railroad company did not join with the other land-owners in the agreement of September 9, 1884, in reference to the use of the river front during seasons of ice. (See Colonel Merrill's letter of September 22, 1884, to the Chief of Engineers.) It would seem, however, that this has little if any bearing on the case in hand.

A petition has recently been circulated (at Mr. Armstrong's instance, I understand), addressed to you in reference to this matter, which has been quite extensively signed by river men. This petition will probably be submitted to you soon.*

I will add that Mr. Armstrong owns or is interested in the land immediately below that of the railroad company, which makes him, of course, particularly interested in this matter, as filling up to any considerable extent along the shore in front of the company's land would naturally shoal the water along his front.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Colonel, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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(4) REPORT OF CAPTAIN H. S. TABER, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Little Rock, Ark., July 1, 1890.

SIR: In accordance with the requirements of General Orders, No. 9, Headquarters Corps of Engineers, U.S. Army, Washington, D. C., dated June 6, 1888, I have the honor to state that there are in this district no piers, breakwaters, locks, dams, or other structures or works built or made in the United States in aid of commerce or navigation that are used, occupied, or injured by a corporation or an individual, except that the Black River from Poplar Bluff, Mo., to Corning, Ark., has been more or less obstructed by the carelessness of loggers in not making up their rafts properly, and also the dam on Black River a few miles below Poplar Bluff has been torn out without doubt by the use of dynamite, as various shattered logs belonging to the dam have been found. I have been unable to ascertain who the offending parties are.

I am, sir, very respectfully, your obedient servant,

H. S. TABER,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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(5) REPORT OF MAJOR JAMES B. QUINN, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Duluth, Minn., June 30, 1890.

GENERAL: Pursuant to the requirements of General Orders, No. 9, Headquarters Corps of Engineers, U. S. Army, June 26, 1888, I have the honor to report as follows:

IMPAIRMENT OF CONNOR'S POINT CHANNEL.

One of the dredging firms at West Superior has been depositing the spoil, taken from private slips, in the immediate vicinity of the dredged

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*Not yet received.

areas at Connor's and Rice's points. It has been the subject of numerous complaints from navigators and property owners where water facilities are damaged, and I have reported one case to the Chief of Engineers with a view to obtaining information as to the course to pursue to stop this deliberate injury to the navigable waters of the Superior and St. Louis bays and the channels dredged therein by the United States. The dredging firm was also notified to stop depositing material in the localities complained of, but no attention has been paid to it.

The extent of the damage to the channels dredged by the United States can not be determined without a careful survey.

Respectfully submitted.

JAMES B. QUINN,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. Army.

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(6) REPORT OF MAJOR CHARLES E. L. B. DAVIS, CORPS OF ENGINEERS.

The following changes have occurred since the report submitted with my annual report for June 30, 1889, viz:

FOX AND WISCONSIN RIVERS, WISCONSIN.

AT APPLETON, LEFT BANK OF RIVER.

	Horse-power.
Appleton Pulp and Paper Mill	300
Atlas Paper-Mill	400
Tioga Paper-Mill	250
Vulcan Paper-Mill	250
Water-Works Company	50
Total	1,250

This water-power was originally created by a wing-dam, built under the laws of Wisconsin by the riparian owner, Mr. Theodore Conkey. Afterwards, in 1852, when the State of Wisconsin built the upper dam at Appleton, across the river, for the purpose of navigation, it was connected with this wing-dam. The present owners derive their title from Mr. Conkey. The power is now maintained by the Government dam.

AT APPLETON, RIGHT BANK OF RIVER.

	Horse-power.
Atlas Paper Company	950
Atlas Paper Company	950
Appleton Boot and Shoe Company	20
Appleton Chair Factory	75
Appleton Electric Light Company, including Appleton Edison Light Company, moved from left bank of river	200
L. A. Peifer & Co., tannery, burnt down, not rebuilt	20
Union Toy Company	40
Total	2,255

This power is maintained by the Upper (Government) Dam and the canal on the right side, and is leased or purchased from the Green Bay and Mississippi Canal Company.

AT APPLETON LOWER DAM.

	Horse-power.
Manufacturing Investment Company, now building, entitled to	350
Pride & Son, pulp-mill	400
Baum & Hume, flour	40
Eagle Fork Company	25
Electric Railway Company	200
Total	1,015

This power is maintained by the Lower (Government) Dam, and is leased from the Green Bay and Mississippi Canal Company.

AT CEDARS DAM (KIMBERLY).

Kimberly and Clark Company, paper-mill, occupying right end of dam by revocable license of Secretary of War, dated March 4, 1889. Expect to use 2,000 to 3,000 horse-power, now using about 2,000 horse-power.

AT LITTLE CHUTE.

	Horse-power.
John Verstegen, flour-mill	130

This power is maintained by the dam at Little Chute, and is leased from the Green Bay and Mississippi Canal Company.

AT KAUKAUNA, LEFT BANK.

	Horse-power.
A. L. Smith, flour-mill	100
Kaukauna Paper Company (leased)	1,500
Kaukauna Lumber and Manufacturing Company	80
American Pulp Company	400
Reuter Brothers (not running), hubs and spokes	50
Total	2,130

This water-power is created and maintained by the dam at Kaukauna, and is leased from the Green Bay and Mississippi Canal Company.

AT DE PERE.

	Horse-power.
John P. Dousman, flour-mill	100
Dunham, Wells & Co., flour-mill	100
Lawton Real Estate and Trust Company (not running)	25
De Pere Land and Water-power Company	250
Total	475

This power is maintained by the dam at De Pere and by private parties. It is held under grant from the legislature of the State of Wisconsin, approved February 9, 1850, to Joshua F. Cox and his heirs and assigns forever, upon certain conditions as to the construction and maintenance of the lock, dam, and canal at the rapids at De Pere. The individual powers were purchased or leased from Cox and his successors.

As already stated, the Government or the public had suffered no injury up to July, 1886, and had been at no expense on account of these water-powers. They are held subject to the rights of navigation, but it appears that mill-owners refuse to acknowledge the decision of the officer in charge as to what the relative rights of the water-power companies and water-users and the public are. The mode, extent, and circumstances of the use of the water-powers for industrial purposes, as far as affects the interests of the Government and of the public in the navigation of the Fox River, will probably be authoritatively decided by

the United States courts in the pending suit against the water-power users at Neenah and Menasha.

The owners of the water-powers under the State charter are inclined to sell or lease water privileges in excess of the low-water discharge of the Fox River throughout the pools created by the dams on the Fox River, and can only be restrained in this vicious practice by legal process.

CHAS. E. L. B. DAVIS,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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(7) REPORT OF CAPTAIN W. L. MARSHALL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., July 10, 1890.

GENERAL: In accordance with section 4 of the river and harbor act of August 5, 1886, and General Orders No. 9, Headquarters Corps of Engineers, June 26, 1888, I have the honor to report the following cases where "piers, breakwaters," etc., under my charge "have been used, occupied, or injured by a corporation or individual" during the fiscal year ending June 30, 1890.

(1) CHICAGO HARBOR, ILLINOIS.

The United States piers so occupied consist principally of those forming the entrance channel to Chicago River.

The United States pier-work commenced on the north side of the river, opposite the center line of Pine street extended. Thence eastward, the property along the channel is owned and the docks occupied as follows (the distances given having reference to linear feet of dock frontage):

	Linear feet.
J. S. Kirk & Co., soap manufacturers, own land and occupy the dock	325
C. H. McCormick's estate own land, and the Western Transit Company occupies the dock	336
The Marble Producers' Company own and occupy	135

The remainder of the land up to the end of the north pier at Ogden's Slip is owned by the Chicago Canal and Dock Company (in all 2,367 linear feet of frontage) and is occupied by—


Lehigh Valley Transportation Company	350
Unoccupied	155
C. L. J. Meyers's lumber-yard	265
Central Vermont Railway Company's warehouse	310
The Globe warehouse	150
Fuller, Warren & Company's warehouse	127
Fitz Simons and Connel Company, contractors	390
Light-house, U. S	170
Total United States north pier	2,713

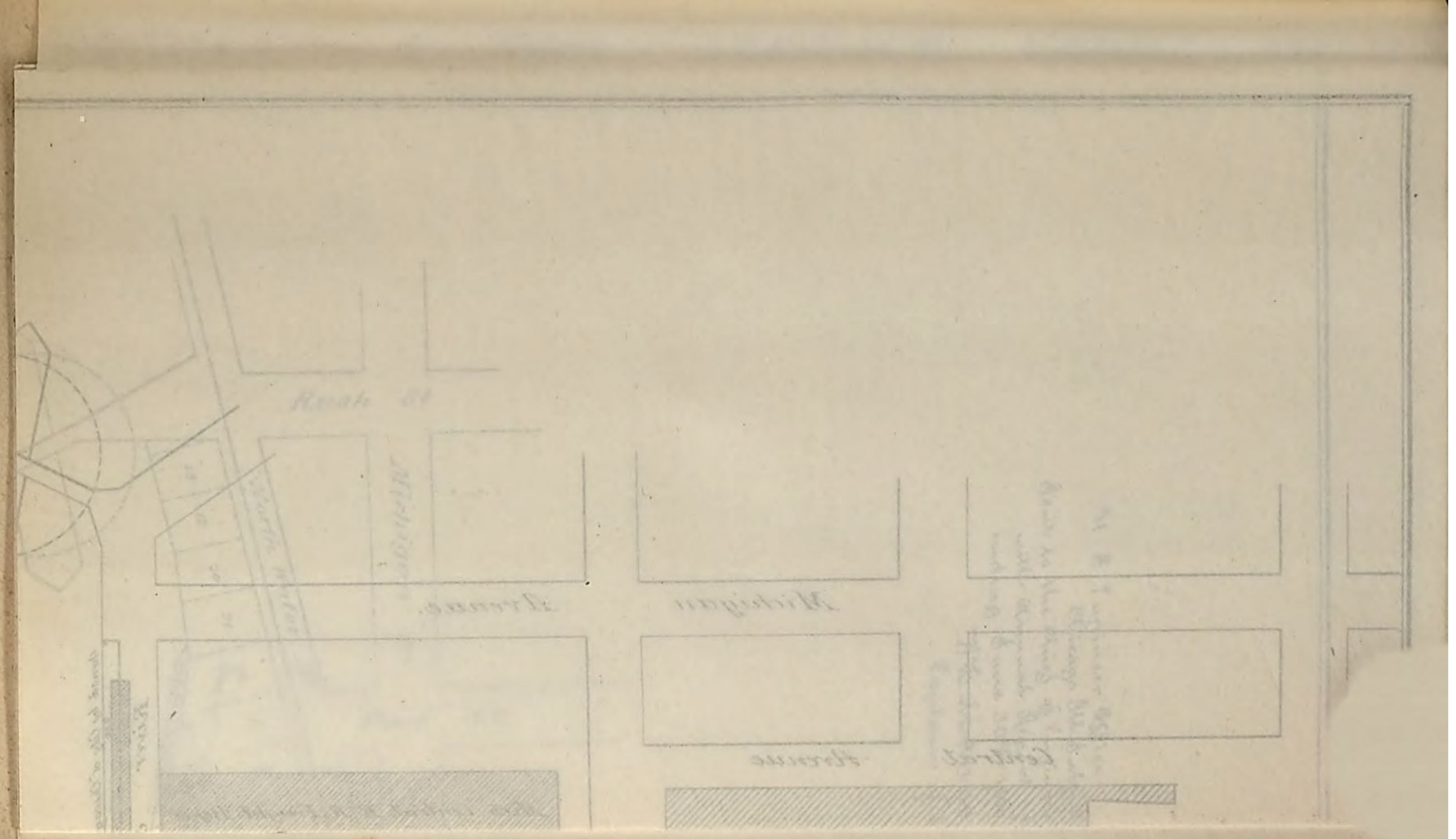
The balance of dock, 450 linear feet, fronting the property of the Chicago Canal and Dock Company, is built by the city of Chicago.

On the south side of the river the United States pier-work was commenced opposite the east line of Michigan avenue. Breaks have been made in three places in this pier by the Illinois Central Railroad Com-

— MAP OF —
CHICAGO HARBOR ILLINOIS
Showing Docks built by the U.S. Government and occupied by PRIVATE CORPORATIONS or INDIVIDUALS.
— 1890. —
— Scale 1 inch = 200 feet. —

U. S. Engineer Office
Chicago Ill. July 10th 1890.
Sent to the Chief of Engineers U. S. Army
with Annual Report for the fiscal year
ending June 30th 1890.
W. L. Marshall.
Captain of Engineers U. S. Army.





pany for the formation of slips. This work is occupied and adjoining land owned as follows:

	Linear feet.
The city of Chicago owns 250 feet and the Michigan Central Railroad Company owns 250 feet of the land, and the dock is occupied by the Goodrich Steam-boat Company a distance of	500
The Illinois Central Railroad Company owns the land and occupies the dock of	219.5
Or up to Slip "A."	
The land is also owned and dock used by the Illinois Central Railroad Company between Slip "A" and Slip "B"	121
And between Slip "B" and Slip "C"	148
East of Slip "C" the land is owned (and made) by said railroad company and occupied by Risser & Warden's coal yard	257
Total United States pier, south side, occupied as above	1,245.5

In addition to the pier just accounted for, and east thereof, is a length of 1,225 feet of United States pier not as yet occupied. A bill is, however, now pending in Congress concerning the use of this pier by private parties. The land adjoining this pier is made and owned by the Illinois Central Railroad Company. The firm of Walker, Whitehead & Co. are the parties desiring to occupy about 700 linear feet of the pier, they having leased the adjacent land for a coal-yard.

East of the coal-yard the land is occupied by Cook & Rathborne for a lumber-yard, but the dock is not used by them.

Besides these docks in the river channel a small portion of the southerly breakwater is occupied by the city of Chicago for some temporary structures, under a revocable license from the Secretary of War, used as workshops in constructing the new water-works inlet tunnel, a shaft for this having been built close to the said breakwater. A portion is also used for storing the materials employed in this work.

A map showing in a yellow tint the piers built by the United States at the river channel, and also by whom those piers are occupied and who owns the adjoining property, is respectfully submitted herewith.

It is perhaps proper to state in connection with this report that as a rule the parties occupying docks as herewith stated have kept such docks in repair at their own expense, and that these piers, with the exception of 700 to 1,000 feet, the use of which is sought by Walker, Whitehead & Co., and the portion of the southerly breakwater outer harbor used by the city of Chicago, have been practically abandoned by the United States and no longer maintained by the United States.

(2) CALUMET HARBOR, ILLINOIS.

On the north side of the harbor all the land adjoining the United States Government pier-work is owned by the Illinois Steel Company, with the exception of a lot 300 feet deep and with 100 linear feet of dock frontage, which has been reserved by the Government for light-house purposes, and upon which is located, besides the old light-house, the office and boat-house for United States harbor works, store-house for tools, etc., and buildings for the new life-saving station, the latter completed during the past year.

The land and dock on both sides of the reservation and as far as to the Steel Company's slip is occupied by the A. R. Bock Lumber Company. East of the slip the piers are in such dilapidated condition as to be absolutely unfit for any use whatever, save that the company has maintained a privy thereon, which reaches partly over the river and is an unsightly nuisance.

On the south side of the harbor land has been made, and is owned by the Calumet and Chicago Canal and Dock Company for a distance of 360 feet adjoining the United States south pier, but this filling is as yet not completed, and is not occupied.

W. L. MARSHALL,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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(8) REPORT OF COLONEL O. M. POE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., August 6, 1890.

GENERAL: In accordance with section 4 of the river and harbor act of August 5, 1886, and General Orders No. 9, Headquarters Corps of Engineers, June 26, 1888, I have the honor to report the following cases where "piers, breakwaters," etc., under my charge "have been used, occupied, or injured by a corporation or individual" during the fiscal year ending June 30, 1890.

(1) *Revetments of St. Mary's Falls Canal, Michigan.*—July 7, 1889, the *Northern Wave* ran into the northeast pier October 9, 1889, the *V. Swain* chipped the coping on the lock-wall. October 17, the *Comrade* ran into the northwest pier near the range lights; damage $358.78. November 2, 1889, the *Fayette Brown* ran into the northeast pier. November 17, 1889, the *Henry Chisholm* ran into the northeast pier. November 20, 1889, the *Livingstone & V. H. Ketcham* ran into the northeast pier.

The above collisions with the northeast pier were all in about the same place. The greatest part of the damage was caused by the *Northern Wave* and the *Fayette Brown*; damage at this point $1,616.20.

May 10, 1890, the *Martin Swain* ran into the south pier below the lock; damage, $44.74. Total injury to revetments during the fiscal year, $2,019.72.

(2) *Pier in front of Fort Brady, used in connection with the St. Mary's Falls Canal, Michigan.*—October 3, 1889, the *Ashland* ran into the pier; damage, $500. May 12, 1890, the *Comrade* ran into the pier; damage, $500. May 24, 1880, the *Frank D. Ewen* ran into the pier; damage, $418.56. Total injury to pier during the fiscal year, $1,418.56.

(3) *Saginaw River, Michigan, Carrollton revetment.*—August 23–24, 1889. At 9 p. m., August 23, owing to sparks from some passing vessel, a fire broke out in the revetment, at a point to which the work of reconstruction had not yet advanced. The fire continued at intervals during the night, and was not finally extinguished until 4 a m. on the 24th of August. The cost to the United States for the services of fire tugs was $74.

(4) *Breakwater at harbor of refuge, Sand Beach, Michigan.*—December 10, 1889, the *Red Wing* collided with the main pier with such force as to throw her anchor on it. She then dragged the anchor along the deck of the pier, causing considerable damage. April 24, 1890, the barge *Col. Brackett* was towed into the harbor in a sinking condition and left about 300 feet southwest of the Commercial Dock. She was sold to Mr. David Dues, of Sand Beach, who took everything of value off the vessel and left her where she lay. Mr. Dues was duly notified that he

must take steps for her removal, but he has not yet done so. May 22, 1890, the *John Plankington* ran into the pier; damage, $76.20. The owner, Mr. R. P. Fitzgerald, of Milwaukee, upon being notified, very promptly paid the above amount, when it was turned into the United States Treasury.

No further use, occupation, or injury to works in my charge than those reported above are known to have occurred during the fiscal year ending June 30, 1890.

Very respectfully, your obedient servant,

O. M. POE,
Colonel, Corps of Engineers,
Bvt. Brig. Gen., U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

APPENDIX A A A.

MAINTENANCE AND REPAIRS OF WASHINGTON AQUEDUCT—WATER SUPPLY, DISTRICT OF COLUMBIA—INCREASING THE WATER SUPPLY OF WASHINGTON, D. C.—ERECTION OF FISH-WAYS AT GREAT FALLS.

REPORT OF LIEUTENANT-COLONEL GEORGE H. ELLIOT, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

IMPROVEMENTS.

1. Washington Aqueduct.
2. Water supply, District of Columbia.
3. Increasing the water supply of Washington, D. C.
4. Erection of fish-ways at Great Falls.

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., July 10, 1890.

GENERAL: I have the honor to transmit herewith report of operations for the following works in my charge for the fiscal year ending June 30, 1890, viz:

Washington Aqueduct.
Water supply, District of Columbia.
Increasing the water supply of Washington, D. C.
Erection of fish-ways at Great Falls.

Very respectfully, your obedient servant,

GEORGE H. ELLIOT,
Lieut. Colonel of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

A A A 1.

WASHINGTON AQUEDUCT.

Appropriations for the Washington Aqueduct are applied to the improvement, the maintenance, and repair of those portions of the Washington water supply, other than the tunnel, that have been placed under the supervision of the Chief of Engineers. The works include the masonry dam, 2,877 feet long, extending from the Maryland to the

Virginia shore at Great Falls of the Potomac, 14 miles west of Washington; the works at Great Falls for regulating the supply to the conduit; the conduit, 9 feet in diameter, from Great Falls the three reservoirs, viz, the receiving reservoir, about 4¼ miles from the city; the distributing reservoir, about 2 miles west of the city, and the high-service reservoir in Georgetown for the supply of the higher portions of that city; the mains by which the water is carried from the reservoirs and delivered into the city's distributing system, and the bridges for supporting the mains across Rock Creek.

On July 17, 1889, in obedience to Special Orders, No. 155, Headquarters of the Army, Adjutant General's Office, July 8, 1889, I relieved Col. John M. Wilson, U. S. Army, lieutenant-colonel of Engineers, of the charge of this work.

During the past year the usual operations for maintaining and preserving the aqueduct have been carried on. The mains have been flushed, the valves oiled and cleaned, the gate-keepers' houses have been repaired, the gates adjusted so as to preserve the water in the distributing reservoir at as high a level as possible, the dams and embankments wherever they have been washed or cut by rains have been repaired, the ditches and culverts along the line of the conduit, on which the safety of the conduit so much depends, have been kept in order, and about 4,231 running feet of ditches have been paved.

Every opportunity that the river would allow has been utilized in the work of replacing the heavy coping of the dam at Great Falls which was carried away by the great freshet of June, 1889, but it has been greatly retarded by the frequent rains of the last year that have kept the depth of water flowing over the dam much greater than in its usual low-water stages. The entire length of the break, 347 feet, in the coping of the dam across the Maryland Channel was repaired during the months of July and August. During the months of September and October a length of 442 feet of the coping of the dam across the Virginia Channel was replaced. Operations were then suspended for the season by reason of high water. In the Virginia Dam there remains the most difficult part of the work, a length of 314 feet, which is now in progress, and every effort will be made to complete it during the low water of this summer if the river will permit.

The receiving reservoir, which was cut out of the system of water supply in 1885 on account of certain defects in the reservoir, was not in use during the last year, and the water from Great Falls was passed around the reservoir by the conduit provided for the purpose. New stop timbers were made for closing its inlet and outlet; the derricks for handling them were repaired, and a survey was made for the purpose of estimating the cost of deepening and lining the margins of the reservoir with rubble-stone.

At the distributing reservoir, while connecting the new 48-inch main with the reservoir, it became necessary to drain the lower division, so that this reservoir was also cut out of the system of supply from the middle of October, 1889, to the 18th of March, 1890, and the water passed around the reservoir in the 7-foot conduit.

During this period the water from Great Falls was supplied directly to the mains without passing through either reservoir. Advantage was taken of the emptying of this reservoir, which had not been done before in about twenty years, to make a number of repairs that had been postponed, some of them a long time, for some such opportune occasion. The 30-inch valve in the old gate-chamber and the 48-inch butterfly-valve closing at the cross-dam between the two divisions of the reser-

voir; the 48-inch pipe, which connects under the bottom of the lower division; the upper division, with the effluent gate-house, were repaired; a chain was attached to the latter valve and fastened to an eye-bolt above the level of the water and within reach, so that if the valve should again get jammed it can be opened; a new staff-gauge was placed on the screen-house; the bottom of the screen-house was carefully cleaned out; the old screen, which had been out of order for a number of years, was removed, and the frame-work for new screens was erected; the new screens, which are to be placed early in the next fiscal year, were contracted for, and the lower division of the reservoir was partially cleaned by removing a great number (449 cart-loads) of shell-fish which were found on the bottom. These when alive are doubtless beneficial to the water, but when the drawing off of the water left the bottom of the reservoir dry it became necessary to remove them to prevent contamination of the reservoir. The bottom of the upper division was partially drained when the lower division was emptied, and, as was to have been expected, a much larger deposit (about 9 inches) of clayey sediment was found, but to have thoroughly removed it would have cost more than the remainder of the appropriation for the fiscal year would allow, and it was therefore deferred.

In making a 48-inch cross connection between the new 48-inch main in the new gate-chamber with the auxiliary gate-house, it became necessary to drain the 7-foot conduit, one-half mile long, which had not been done before inmany years, and it was found to contain a large amount of sediment (clay mixed with a little sand), varying from 2 feet deep at the upper end to about 8 inches at its lower end, which has been removed. This sediment was doubtless deposited during long intervals, extending through many years that this conduit has not been in use and when the water within it was still, but it has been in use I believe a part of every year, and especially during the five months of the last year, when the distributing reservoir was not in use, and the fact that the deposit was not moved out of the conduit during these times, when the water flowed with a velocity of at least 1.25 feet per second, is worthy of adding to the meager records of experiments on the power of the water of streams in moving materials along their bottoms.

The fences on the southerly side of the conduit road between the distributing reservoir and the top of Foxhall Hill, which it was necessary to remove in order to lay the 40-inch main, were replaced on the lines of the public land. I caused these lines to be re-established by the official surveyor of the District of Columbia, and they have been marked by permanent stone monuments. I found that in several cases the old fence lines and also private houses had encroached on the public land, and the necessary steps will be taken to have the latter removed.

The flooring of the Aqueduct Bridge over Rock Creek at Pennsylvania avenue, which had been worn out, was renewed, and the iron-work was carefully examined and the bolts which were found loose were tightened up.

The wire fence on the southerly and westerly sides of the lands of the distributing reservoir, for the exclusion of cattle from the slopes of the dams, which was commenced several years ago but not completed, was completed by the building of about 1,200 feet of this fence.

While the water was drained from the 36-inch main for the purpose of making connection with the 48-inch main near Foundry Branch, the broken valve in the blow-off from the former main in that stream was replaced; 153 feet of 8-inch pipe leading from the blow-off to the south

end of the culvert under the Chesapeake and Ohio Canal were laid, and the stone-paving removed for this purpose was relaid. The valve in the blow-off from the 36-inch main at Foundry Branch gate-chamber, which has also been useless for some years, was repaired during the connection between the 48-inch main and the 36-inch main at the distributing reservoir. Both of these important repairs have been waiting for many years for such opportunities.

In the supply mains there has been but one serious break during the year. In September last, when I was excavating for the connection through the dam of the distributing reservoir of the new 48-inch main with the reservoir, a large quantity of running water was discovered which greatly interfered with the work, and when we got deeper was found to come from a large longitudinal crack in the bottom of the section of the 36-inch main that was next outside the old gate-chamber and at a depth of about 30 feet below the surface of the earthen dam. This break was repaired with considerable difficulty and expense, and although it was not so extensive as some of the breaks that have occurred in the mains at other places (where large sections of the main were blown out by the pressure of the water), the danger of again burying the 36-inch main and the other old mains alongside of it as well as the new 48-inch main under so great a depth and pressure of earth, especially as this earth was the dam of the reservoir, led me to propose the extension of the old gate-chamber quite through the dam. You approved the plan and it was executed, so that all the mains in their passage through the dam are now in a vaulted gallery, in which, should a break occur in any of them, no harm can happen to the dam, and repairs can readily be made.

During the excavation of the trench for the 48-inch main, whenever the old mains were uncovered, either in the city or country, their joints were carefully examined. A few were found "weeping," and they were carefully recalked.

On the 26th of December, 1889, I addressed you the following letter, referring to the danger to the distributing reservoir of the close proximity of the Drovers' Rest cattle-market:

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., December 26, 1889.

GENERAL: In the gore or angle between the Conduit road and the New-cut road west of this city are the pens of the Drovers' Rest cattle-market, the land occupied by which is separated from the distributing reservoir of the Washington Aqueduct only by the width of the Conduit road, or about 60 feet.

The conduit connecting the influent gate-house with the auxiliary gate-house underlies the Conduit road, which was constructed and is owned by the United States.

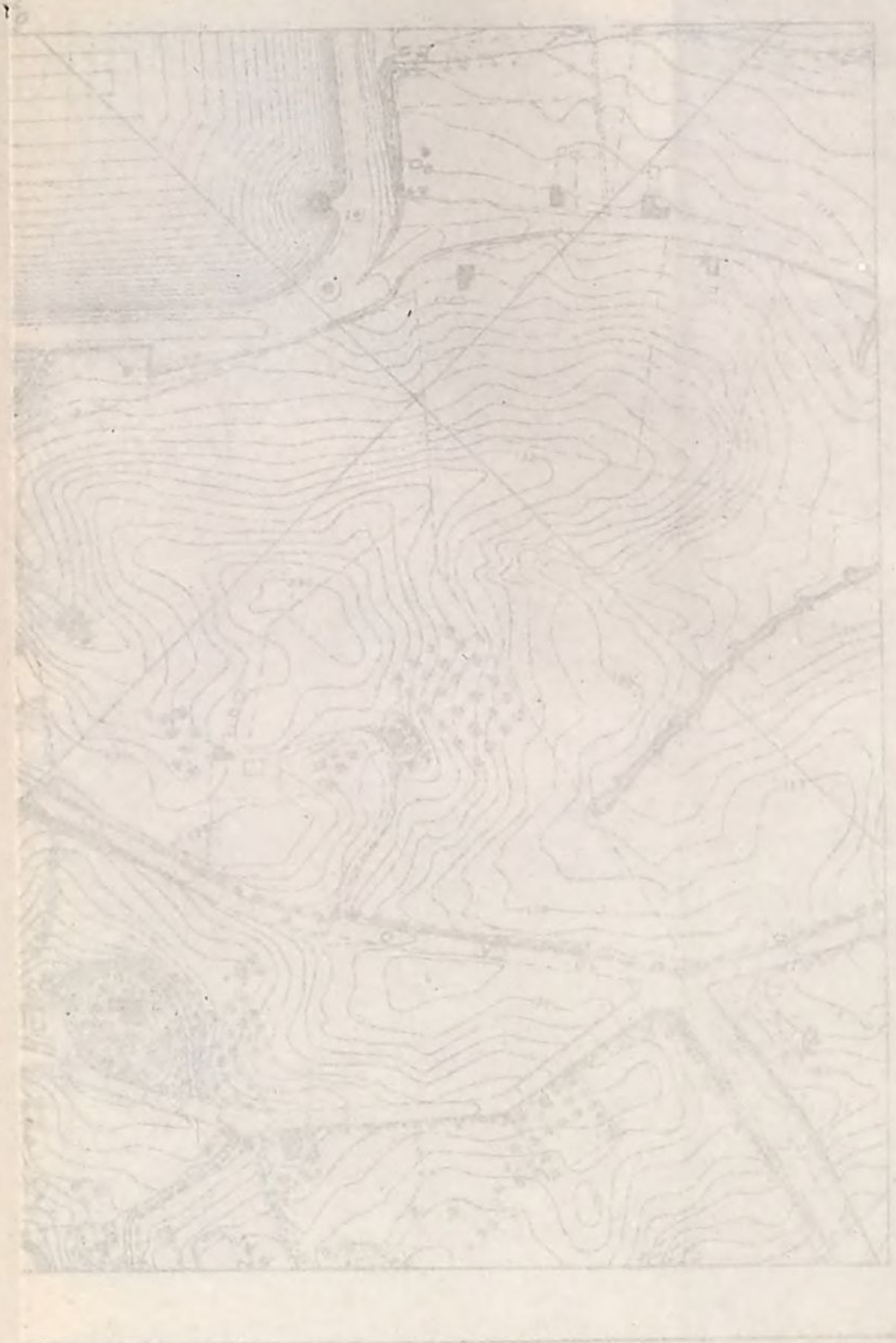
All the rain-water which falls into and around the pens of the cattle-market flows down to this road, and sometimes it overflows the road and is only kept out of the reservoir by the base-board of the reservoir fence, so that there is a constant danger that in some exceptional storm or shower it will get into the reservoir and contaminate the water supply of the city.

In my judgment it would be wise to avert this danger by the purchase by the United States of the land occupied by these cattle-pens.

In the speculative condition of lands in the vicinity of Washington it is difficult to estimate the value of this land, but I do not believe that a jury of condemnation would assess it at more than $800 per acre, if as much. Improvements have been less rapid on this than on other approaches to the city, and I am told that as a cattle-market the Drovers' Rest has been declining for some years; that while formerly there were some times as many as 1,000 cattle, 4,000 sheep, and 150 hogs brought to this market the nights before market days (Mondays), most of the cattle coming to Washington for slaughtering are now taken to the new stock-yard near Benning's, and that rarely more than 250 cattle and 800 sheep are brought to the Drovers' Rest.

The area of land occupied by the pens at Drovers' Rest, together with a small area of wet land adjoining it on the city side, which should also be purchased, for the

H EUG 30



To accompany my letter to the Chief of Engineers of this date

Office of Washington Aqueduct

Dec. 26. 1889

Eugene H. Elliot.

Lieut, Col. of Engineers



Drawn by J.A.Flemer, U.S.C.&G.S.

Feet

100 50 0 500 1000 1500 2000 2500

H Eng 90

purpose of controlling the drainage from one or more slaughter-houses lying on the northerly side of the New Cut road, which drainage also flows to the Conduit road opposite the reservoir, does not exceed 5 acres.

In view of the facts herein presented, I respectfully recommend that Congress may be asked to appropriate for the purchase of this land the sum of $4,000, or such sum as a jury of condemnation, to be appointed by the court in the usual manner, may consider its value; and that for the cost of a survey by a sworn surveyor, for jury fees and other expenses of condemnation, for removing the cattle-pens, clearing up and fencing the ground, for the works for controlling the drainage, and for other necessary improvements, the further sum of $1,500 be appropriated, making for all the purposes mentioned the sum of $5,500.

Section 15 W. of the map of the recent topographical survey of the District of Columbia, on which I have shown in red lines the boundaries of the land recommended to be purchased, is herewith inclosed.

Very respectfully, your obedient servant,

GEORGE H. ELLIOT,
Lieutenant-Colonel of Engineers, U. S. Army.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.,
Washington, D. C.

The bill appropriating for the expenses of the aqueduct for the next fiscal year provides the sum of $5,500 for the purchase and the improvements recommended, but the asking price of lands in the vicinity has appreciated so much since the date of my letter that it is doubtful if the purchase can be accomplished.

RECOMMENDATIONS FOR IMPROVEMENTS.

The aqueduct and the works connected with it are generally in excellent condition, but there are several improvements, mainly in respect of the quality of the water furnished to the city and the protection of the conduit, that are urgently needed.

BETTER WATER.

Now that the city is everywhere abundantly supplied with water except at a few points where its proper distribution is interfered with by the small size, and the reduction in capacity by internal corrosion, of the city's street mains and the service-pipes leading from them to residences, the most important work to be done in connection with the aqueduct is to furnish the city with better water, or, since the water of the Potomac as brought from Great Falls is, I am convinced, perfectly wholesome at all times, it would be more correct to say, with clearer water.

During the last winter and spring, when the new gate-chamber was being constructed in the dam of the distributing reservoir and the 48-inch main was being connected with the reservoir, it was necessary—as the receiving reservoir was, as it has been for several years, out of service—to empty the distributing reservoir, and to bring the water directly to the city from Great Falls, without giving it any time whatever for depositing the earthy matter carried down to the upper Potomac and its tributaries from its water-shed by every storm and shower, and most abundantly in winter and early spring, by reason of the alternate freezing and thawing of the ground.

This muddiness of the water supplied to the city was more noticeable during a portion of the last year, for the reason just given, but it is a defect that has always existed.

The following table gives the number of days in the four years end-

ing June 30, 1889, on which the water had different degrees of turbidity at Great Falls:

Fiscal year.	Clear.	Slightly turbid.	Turbid.	Very turbid.
1885–'86	127	36	51	151
1886–'87	164	29	51	121
1887–'88	194	15	26	131
1888–'89	147	33	50	135
Average for 4 years	158	28	44	134

The following table gives the number of days in the four years ending June 30, 1889, on which the water had different degrees of turbidity at the effluent gate-house at the distributing reservoir, after passing through the reservoir to the mains leading to the city:

Fiscal year.	Clear.	Slightly turbid.	Turbid.	Very turbid.
1885–'86	147	35	72	111
1886–'87	256	39	32	38
1887–'88	240	16	52	58
1888–'89	193	24	64	84
Average for 4 years	209	28	55	73

It will be observed that the total time that the water was "turbid" and "very turbid" at the distributing reservoir was only about two-thirds of the total time that it was "turbid" and "very turbid" at Great Falls, and this great improvement in the water supplied to the city, as compared with its condition when it entered the conduit was due to the time, small as it was, given for depositing its earthy (clayey) matter in the distributing reservoir.

Filtering the water consumed by the cities of Washington and Georgetown would be enormously expensive (it has been estimated that the first cost of filtration works would be from $600,000 to $800,000, and the annual cost from $18,000 to $43,000, according to the plan adopted), and I do not believe it to be necessary.

Turbidity does not necessarily make waters unwholesome. The clearest waters are sometimes the most dangerous because they are so deceptive, and filtration can, at most, only make waters clear.

During the times of its turbidity the Potomac water has caused resort to the clear but deceptive well waters of the city for drinking purposes, and they doubtless have caused disease, which has been attributed to Potomac water; and some years ago, when the Potomac water was allowed to flow through the receiving reservoir and mingle with the water of this reservoir, it had a disagreeable, fishy, and oily taste and smell, and there was much complaint, but the Potomac water itself, brought either directly from Great Falls or through the distributing reservoir, has never even in its worst condition been proved to be unhealthful. On the contrary, it has been generally believed to be one of the best in the country.

Filtration then being out of the question, a comparison of the foregoing tables clearly points out the most important step to be taken for improving the condition of the Potomac water.

It is to provide an additional settling basin, so that when the river is

turbid the water can have a longer time for depositing its sedimentary matter before passing into the mains.

This can be done by improving the receiving reservoir.

The receiving reservoir about 2 miles, following the Conduit road, above the distributing reservoir, has about the same area as the latter, and contains about the same available amount of water.

Its perimeter has a length of about 2 miles. The conduit from Great Falls to the distributing reservoir passes close to a portion of the margin of the receiving reservoir, and there is an inlet from the conduit to the latter reservoir at its upper end, and an outlet from the reservoir to the conduit at its lower end. They are so arranged that the water in its route from Great Falls to the distributing reservoir can be made to pass either directly through the conduit and around the receiving reservoir to the distributing reservoir, or through the receiving reservoir, as may be desired.

It was contemplated in the original design for the aqueduct that the water from Great Falls should always pass through the receiving reservoir, and the latter was intended to serve mainly as a settling basin, but its use as such, and all use, was suspended some years ago.

Unlike the distributing reservoir, which has no water-shed, the receiving reservoir has an extended water-shed of about 4,000 acres. It is mainly to the northward of the reservoir, its northern border crossing the Tennallyton and Rockville road, about $2\frac{1}{2}$ miles above Tennallytown. Its eastern border follows pretty closely the Loughborough and the Tennallytown and Rockville roads, and its general width from east to west is about 2 miles. The greater part of the area of the water-shed is very hilly, and nearly the whole of it is devoted to cultivation and grazing.

The population upon it is quite large, and it is rapidly increasing. The water falling upon this area is carried to the reservoir by several streams, one of which, Powder Mill Branch, is of considerable size, and they carry in storms and heavy showers great quantities of detritus, which is rapidly shoaling the reservoir.

It is not possible with the reservoir in its present condition to exclude the water from its water-shed or to prevent its mingling with the water from Great Falls, were the latter allowed to pass through the reservoir, and frequent complaints in the public press and by the water-takers, in respect of the quality of its water, led some years ago to its being cut out from the system of water-supply to the city.

These complaints are believed to have been well founded, for the following reasons:

First. Every storm and heavy shower brings down to the reservoir, through the streams that lead into it and directly from the hill-sides, not only a great quantity of muddy water which roils the reservoir, but probably some of the fertilizers and other deleterious substances from the cultivated and grazing lands of its water-shed. In fact, this reservoir has the usual defects of reservoirs surrounded by and supplied from cultivated and inhabited districts.

Second. A considerable portion of the margin of the reservoir is shoal, with soft muddy bottom, and the waves stir up the mud and add to the muddy water brought down by the streams.

Third. In other portions of the shoal water, near the shore, there is a luxuriant growth of water plants of various kinds, and the water there being quiet and protected from the waves, it is supposed there is promoted in these places growths of *Algæ*, and other minute vegetable substances that have given much trouble in the reservoirs of other

cities, as well as in the receiving reservoir, to which is attributed the offensive oily and fishy smell and taste of their waters at some seasons of the year, especially in hot weather.

This was the particular cause of complaint in Washington when this reservoir was thrown out of service.

But little complaint, if any, has been made on this score since the water has been drawn into the mains through the distributing reservoir or directly from Great Falls.

The receiving reservoir is admirably suited for settling purposes, if all water be excluded from it except the water from the Potomac, and the margins be deepened and protected.

These can readily be done if Congress will grant the necessary appropriations.

Captain Symons, of the Engineers, conceived an excellent and I believe the only practicable project for the former when he was connected with this office, and it and the drawings illustrating it, may be found in the Report of the Chief of Engineers for 1885, pages 2464–2468.

His project, which I have carefully examined and tested, is to take the waters of East Creek (the stream farthest to the eastward that pollutes the reservoir), and conduct it in an open and paved channel to Mill Creek, together with all the water falling directly into the reservoir from the hills between these two streams; then to take the combined waters of both streams and the water which falls directly into the reservoir from the hill-sides between Mill Creek and Powder Mill Branch, by a proportionally larger channel and a short tunnel to Powder Mill Branch. The combined waters of all the streams are then to be taken by a still larger channel and another short tunnel to a natural watercourse below the reservoir, known as Little Falls Branch.

To catch and throw all the water of the streams into these channels and connecting tunnels, small dams are to be erected across the mouths of the streams below the points where the artificial channels enter and leave their basins, which points are in all cases as close to the reservoir as possible.

The work is planned to give the shortest tunnel lines possible, and both the channels and the tunnels were computed to carry off the greatest known rainfall.

The plan would make the receiving reservoir, which cost many thousands of dollars and is now useless, fully as valuable for settling purposes, and as completely shut off from all polluting influences as the distributing reservoir, by absolutely cutting off from access to the reservoir all waters from its water-shed, excepting that part of it which is now the property of the United States and under the control of this office, and excepting also several small parcels of land amounting to between 16 and 17 acres, which it would be necessary to buy. By it the receiving reservoir would become a distributing reservoir and the time allowed for settling would be considerably more than double the time now allowed, for the distance now traversed by the water in passing through the distributing reservoir between its points of entrance and exit being 2,200 feet, and the additional distance that it would traverse at the receiving reservoir being 3,600 feet, the total distance would be 5,800 feet, or considerably more than 1 mile. It would give the water from Great Falls after reaching the "north connection" of the receiving reservoir a variety of routes for reaching the mains leading to the city, and either could be adopted as the varying conditions of the water might require, as follows: It could be made to pass through the receiv-

ing reservoir, thence through the conduit to the distributing reservoir, and through this reservoir, or it could be made to pass around the receiving reservoir and thence to and through the distributing reservoir, using either reservoir alternately as a settling basin, or, when the water at Great Falls is quite clear, as it is (see the foregoing table) about one-half of the time, it could be made to pass from Great Falls directly into the mains, without passing through either reservoir.

Captain Symons's estimate of the cost of excluding the water of the surrounding country from the receiving reservoir, including the purchase of the small amount of land required, and the cost of completing the fencing of the reservoir lands, is $130,000. From this I would deduct $15,346, his estimated cost of deepening and protecting the margins of the reservoir, as far as was possible at the time of his report, (the water could not then be drawn from the reservoir without great and prolonged inconvenience to the people of Washington), and add $8,000 for a probable increase in the value of the land to be acquired, and 5 cents per cubic yard to his estimated cost of earth excavation, or $1,130, making in round numbers $123,800.

To obviate the defects of the reservoir caused by shoal water, I would deepen the water everywhere at its margins to 12 feet, and protect the sides by slope-walls of dry rubble-stone 12 inches thick laid upon a lining of broken stone 6 inches thick, precisely as the sides of the distributing reservoir are now protected, at the following estimated cost:

148,300 cubic yards of excavation, at 35 cents	$51,905.00
16,400 cubic yards of dry stone masonry, at $4.50	73,800.00
8,200 cubic yards of broken stone lining, at $2.50	20,500.00
	146,205.00
Add 10 per cent. for contingencies	14,620.50
	160,825.50

Adding $123,800, the estimated cost of cutting off all access of the water from the water-shed of this reservoir to the reservoir, and we have for the thorough improvement and completion of the receiving reservoir $284,625.

The improvement of the receiving reservoir, as just indicated, would so much rid our Potomac water of its turbidity as to make it incomparably better than it is every winter and spring, but I would recommend in addition another step in this direction.

LOWERING THE HEIGHT OF THE CROSS-DAM IN THE DISTRIBUTING RESERVOIR.

The lower reservoir, the distributing reservoir, is divided about halfway between the influent and the effluent gate-houses, by a cross-dam, in the middle of the length of which is a narrow cut lined with masonry, through which all the water on its way to the effluent gate-houses, where it enters the mains, must pass.

The draught through this cut is so strong that the major part of the water is drawn straight from the influent gate-house, which is in a corner of the upper division, the settling division, to the cut, so that when the water coming down the conduit is turbid it does not diffuse itself through the whole body of water in this division (110,000,000 gallons), as it should in order that the greatest amount of settling be done.

Neither is the water after it passes through the cut properly distributed through the lower division, which contains about 60,000,000 gallons, for the reason that the draught from the cut to the head of the mains

leading to the city from the lower end of the division is so strong that the water all passes in a comparatively narrow stream straight to these mains, so that it also gets very little chance to settle in this division.

Now, as the upper layer of any body of water not quite free of turbidity and in process of settling is the clearest, if the top of the dam be lowered far enough to allow only a thin sheet of water to pass over it, as was the original design of General Meigs when he constructed the aqueduct, we should have in each division a very effective additional means of clarifying the aqueduct water, and I believe that, this improvement in the distributing reservoir being made and the receiving reservoir being improved as recommended, there would be but rarely, if any, complaint of muddy water.

I estimate the cost of this improvement at the distributing reservoir, by lowering the cross-dam, at $12,500.

PROTECTION OF THE INLET TO THE CONDUIT AT GREAT FALLS.

The bank of the Chesapeake and Ohio Canal which runs parallel to the Potomac at Great Falls, and about 150 feet from it, is about 16½ feet higher than the uncovered chamber, just above the Maryland end of the aqueduct dam, that forms the inlet from the river to the conduit.

In the flood of November, 1887, which rose at Great Falls to the height of 160 feet above the datum of the aqueduct, or 12 feet higher than the crest of the dam, the canal bank at a point opposite the inlet was washed down to the river and a part of it into the inlet. I quote from the annual report of the aqueduct for 1878:

> The masonry forming the arch of the feeder was uncovered from a point near the middle of the canal to the mouth of the feeder, a distance of 150 feet. The chamber at the head of the aqueduct was filled with stones that had formed the slope-wall of the canal, and the aqueduct feeder for a distance of 300 feet was filled with débris to depths varying from 3 to 6 feet, so as to entirely stop the flow of water during the ordinary low stages of the river.

In the still higher flood of June, 1889, which rose to the height of 16 feet over the aqueduct dam, the canal bank was again washed down to the river, but fortunately the damage did not occur immediately opposite the inlet to the conduit, but from 200 feet to 400 feet higher up, so that, the major part of the débris being left on the margin of the river and a part of it being carried over the dam, not so much filling of the inlet to the conduit was done, but, as in the flood of 1887, it was partially obstructed. The annual report of the aqueduct for 1889 says:

> The banks of the Chesapeake and Ohio Canal above and below the mouth of the conduit were carried away, and that opposite the conduit was threatened; a number of men were kept at work on this bank during the freshet, and it is believed that this had it not been for the energetic work of force and the widening and strengthening of the bank at this locality in April, great damages would have occurred at the mouth of the conduit.

It will be observed that in the freshet of 1877 not only the inlet-chamber, but the conduit itself, was filled to a depth of from 3 to 6 feet *for a distance of* 300 *feet in from its mouth*, but the water in the river being at a high stage there was still water-way enough in the conduit above the débris to enable the supply to the city to be kept up. Had a complete closure of the mouth of the conduit occurred, with 12 to 16 feet of water over it, there would have been no possible way, with the torrent raging over the mouth, to remove the obstruction before the river subsided, and the water-supply to the city would have been cut off.

There is no more important part of our system of water-supply to be carefully guarded than the head of the conduit at Great Falls, and in order to avert dangers like those of 1877 and 1889, to which the water-supply is liable in every freshet, a masonry wall should be built between the river and the canal bank, rising a few feet higher than the latter and extending up-river from the mouth of the conduit as far as the limit of the Government land, and thence, at about a right angle and still on the Government land, to the shore of the river. I estimate the cost of this wall at $5,000.

EXTENSION OF OUTLET OF WASTE-WEIR NO. 3.

In order to provide means for emptying the conduit in case of a break in it, or for any purpose of repair, and to regulate the quantity of water passing down the conduit, three waste-weirs or openings from the conduit are provided in its 11½ miles of length. One of the most important of them is waste-weir No. 3, which is between the receiving reservoir and the distributing reservoir, and about ½ mile above the latter. One of its most important functions is to enable us to control the height of water in the distributing reservoir, so that, on the one hand, it shall not fall below the height required to give the best possible supply to the city, and, on the other, it shall not rise so high as to endanger the dams of the reservoir. This is ordinarily done by telephonic orders to the watchman gate keeper at Great Falls, who is in charge of the gates at the head of the conduit, but in case of a break in the telephone line, and communication with him, except by mail, being cut off, reliance must be had on the waste-weirs, and especially on No. 3, which is in charge of the watchman gate-keeper at the distributing reservoir. The overflow from this waste-weir is, for the distance of about 270 feet, in a deep gully through private property to a natural water-course and thence under the Chesapeake and Ohio Canal to the Potomac. Property in this vicinity is getting to be valuable, streets are being laid out through it, and the outflow from the waste-weir is liable to be obstructed by the filling of the gully by the owners of the land. The difficulty can be obviated by laying a 36-inch cast-iron pipe in the gully from the waste-weir to the natural water-course, at an estimated expense of $2,500.

DEEPENING THE DISTRIBUTING RESERVOIR.

The present bottom of the distributing reservoir being at reference 135 above the aqueduct datum, and the flow-line of the reservoir being at reference 146 above this datum, the available depth of water is 11 feet.

It has often been recommended in former annual reports that the depth be increased 13 feet, or to reference 122, the depth of the axes of the four 48-inch connections between the screen-house and the gate-chamber.

This would increase the storage capacity of the reservoir from about 170,000,000 gallons to about 290,000,000 gallons and add to the coolness of the water and also to its purity, for, unlike the receiving reservoir, which is nearly surrounded by woods, the distributing reservoir is fully exposed to winds, and the waves are sometimes so great as to disturb the bottom and make the water roily.

This should be done, bermes of 10 feet in width should be left at the foot of the present slope-walls protecting the sides of the reservoir, the

tops of these bermes should be paved, and the deepened portions of the sides should be protected by slope-walls of dry rubble masonry 12 inches thick, laid on a broken-stone lining 6 inches thick.

I estimate the cost of the work at $290,000 in round numbers, as follows:

580,000 cubic yards of excavation, at 35 cents	$203,000
10,500 cubic yards of rubble slope-wall, at $4.50	47,250
5,300 cubic yards of broken-stone lining, at $2.50	13,250
	263,500
Add 10 per cent. for contingencies	26,350
	289,850

I consider the deepening of this reservoir to be of very great importance for the reasons given, and it should be done as soon as appropriations can be obtained for it, but as the improvement of the quality of the aqueduct water is now of primary importance, I would recommend that the deepening be deferred until after the improvement of the receiving reservoir and the lowering of the dam of the distributing reservoir shall be completed, as hereinbefore recommended.

STORAGE YARDS.

I have provided supplies for use in case of breaks in the 48-inch and other mains, comprising sections of pipe, curves, crosses, reducers, sleeves, etc., a heavy wagon for hauling them where needed, lifting jacks, and efficient pumps; also machinery for lowering the pipes in the trenches and the implements and material required for handling and calking.

A portion of these supplies has been placed in a yard which I have arranged on the public land at the distributing reservoir, for use in the country portions of the routes of the mains, and the remainder, for use in the city portions of these routes, has been placed in a portion of Twenty-seventh street, near M Street Bridge, which has been loaned for the purpose by the District government until the street is wanted for improvement.

As we shall not be able, probably, to retain this place except for a short time, a permanent yard in the city should be purchased for use as a storage yard. It should be near this office and at or near the grade of the street, so that the heavy castings and machinery required for repairs can be quickly gotten out.

I believe that a suitable lot can be obtained by purchase, or, if need be, by condemnation, for $7,500, and I recommend an appropriation of this amount for the purpose.

CLEANING THE BOTTOM OF THE DISTRIBUTING RESERVOIR.

The sedimentary deposits of about twenty years, within which time the distributing reservoir has not been cleaned out, have raised the bottom of its upper division, the settling division, about 9 inches, and of the lower division about 4 inches.

These deposits have diminished the capacity of the reservoir about 8,000,000 gallons, and although it is probable that these deposits, which are mostly clay, are not deleterious to the water, they should be removed as soon as an appropriation can be obtained for the purpose. It would require the removal of about 39,500 cubic yards, the estimated cost of which, at 35 cents per cubic yard, is $13,825.

DEFICIENCY OF AIR-VALVES AND BLOW-OFFS IN THE OLD MAINS.

It is important that more efficient facilities be provided for emptying and filling the old mains in case of accident and of making connections from main to main.

In either case a section of the main must be cut out and a new piece inserted, but before this can be done, the main valve at whatever distance on either side must be shut, and the section of the main between these two valves, generally more than a mile long, must be emptied of its water. The time required for emptying depends not only on the sizes of the blow-offs in the valleys crossed by the mains, but also on the sizes of the air-valves provided at the summits, for the water can not, of course, in any case, be gotten out of a main any faster than the air required to take its place can be gotten in.

In making the connections at New Jersey avenue and L street between the 36-inch main and the 24-inch by-pass, on the night of the 14th of April last, more than five hours were consumed in freeing the main of water, owing to insufficient blow-offs and air-valves in the 36-inch main, and the refilling of the main after the connection had been made was so much prolonged by the want of proper valves for the egress of the air that it was nearly noon of the next day before the charging of the main was completed.

Similar delays occurred at each of the numerous connections between the mains that were made after the 48-inch main was completed, and I was in each case obliged, in getting the air into the mains for emptying and out of them for filling them again with water, to have recourse not only to fire hydrants, but to the service-pipe spigots in the houses in the vicinities of these connections. These delays are so expensive, night work costing double the rates of day work, and the danger in case of fire in the district cut off from its supply of water is so great, that I hoped to be able to submit with this report an estimate of the cost of a complete furnishing of the old mains with efficient blow-offs and air-valves, but I have not yet been able to get the details of a patented plan for tapping with large taps water-mains under pressure which I understand exists, and which would very much reduce the time required for inserting each blow-off and air-valve, and the cost of it.

DESIRED PROVISION IN RESPECT OF APPROPRIATIONS FOR THE AQUEDUCT.

Appropriations for the aqueduct are fiscal year appropriations and their availability terminates on the 30th of June of each year. Whenever appropriations are delayed there is liable to be a time in the early part of every other fiscal year during which, should a break occur in a main either in the city or in the country this side of the distributing reservoir, or in the conduit, or should any disaster occur at the reservoir or at Great Falls, there is no money available for repairs.

An example of the urgent need of a change in this respect is the repair of the dam which collects the water for supplying the conduit at Great Falls. It is a most important work and one that can be done only at the lowest stages of the river. Every rain stops it and causes a loss of time and money. For a few weeks preceding the close of the fiscal year just passed there had been an exceptionably favorable time for the work, and it was pushed forward with all the rapidity possible, up to the evening of the 30th of June, when, by reason of the limit of the appropriation as to time, it was necessary to discharge the workmen

and wait for a new appropriation which, even if it should be made early in July, will not be available at the Treasury until some weeks later.

If the appropriations for the aqueduct should be made available until expended, some of the less urgent repairs towards the end of the year could be postponed until the next appropriation should become available, so that there would always be money in hand for repairing a break in a main, or for any other work like the one mentioned at Great Falls, that can not be postponed without loss.

A leak in one of the city's old and decayed street mains, or in one of the hundreds of small service-pipes that cross the route of the 48-inch main, for instance, by undermining it may cause it to break, and the quantity of water that would be discharged on the street, especially in the low levels of the route, would be so enormous that property and even life itself might be endangered.

And in case of appropriations for specific works like those I have recommended, it is sometimes not advantageous, either in respect of economy or the quality of the work, to oblige the work to be fully completed at the end of the fiscal year.

Sometimes by reason of the late date at which appropriations become available, or of the weather, or of the condition of the river, the work can not be fully completed within this time without hurrying it so much as to be detrimental to the interest of the Government. I do not know of any appropriations that more require to be made available until expended, like appropriations for river and harbor improvements, than appropriations for the Washington Aqueduct. I urgently recommend, therefore, that it be done, and also that the same facilities that were provided in the act of March 2, 1889, making an appropriation for the construction of the 48-inch main, be provided for every part of the work pertaining to the aqueduct, and beg to suggest that the following clause be attached to the next appropriations for the aqueduct, and be made to operate on all future appropriations for it:

Provided, That all appropriations for the Washington Aqueduct shall be available until expended, and if it shall appear to the Secretary of War, on the report of the Chief of Engineers, that for any cause any work pertaining to said aqueduct can not be carried on, or material therefor can not be obtained as rapidly as is necessary for the best and most vigorous prosecution of it, he is authorized to provide material by purchase in open market, or by contract for the fabrication thereof, and to carry on the work by day's labor or otherwise, as may seem to him expedient.

The usual annual measuring of the amount of water used and wasted in the city was made during the twenty-four hours ending at 6 o'clock a. m. on the 26th of June, and the result will be found in Table 1. It will be observed that the outflow from the distributing reservoir was 35,541,845 gallons, an increase of 7,833,066 gallons over the outflow in the 24 hours ending at 6 o'clock a. m. on June 29, 1889. The day was one of the hottest of the season, the thermometer at 2 o'clock p. m. reading 95° in the shade, but the principal cause of the great increase over last year was the new draft on the reservoir by the 48-inch main. Hereafter it is to be presumed the annual increase will not very much exceed that of recent years.

The height of the water above the dam at the inlet to the aqueduct at Great Falls varied during the year from a minimum of 0.7 foot on July 12 and 13, 1889, to a maximum of 4.7 feet on May 27, 1890.

Formerly the average pressures on the 36-inch and the 30-inch mains as recorded in this office daily at 9 a. m., was 29.9 pounds per square inch. Since the commencement of the use of the 48-inch main and the

division of the city into high and low service areas, the gauge connected with the 48-inch main has shown an average pressure of about 40 pounds per square inch, and the gauges connected with the 36-inch and 30-inch mains have each shown an average gain of from 9 to 10 pounds.

Mr. R. C. Smead has performed his duties in connection with the 48-inch main and of superintending the working of the aqueduct and its adjuncts satisfactorily during the year. Mr. Thomas Sullivan, Mr. John Halloran, and Mr. Daniel Harrington, for many years watchmen gate-keepers at Great Falls and at the receiving and distributing reservoirs, have attended to their important duties faithfully.

Mr. Sullivan and Mr. Harrington, in addition to their other duties, have skillfully and energetically acted as foremen of large parties of laborers engaged on the works of repair at Great Falls and at the distributing reservoir.

TABLE 1.—*Showing hourly flow from distributing reservoir for the twenty-four hours ending June 26, 1890. City temperature in the shade at 2 p. m., 95°.*

Date.	Fall.	Outflow per hour.	Date.	Fall.	Outflow per hour.
June 25—	*Feet.*	*Gallons.*	June 25—	*Feet.*	*Gallons.*
From 6 a. m. to 7 a. m	.12	1,690,227	From 8 p. m. to 9 p. m	.10	1,388,768
From 7 a. m. to 8 a. m	.11	1,547,842	From 9 p. m. to 10 p. m	.10	1,387,556
From 8 a. m. to 9 a. m	.13	1,827,377	From 10 p. m. to 11 p. m	.09	1,247,765
From 9 a. m. to 10 a. m	.12	1,684,992	From 11 p. m. to 12 m	.09	1,246,783
From 10 a. m. to 11 a. m	.13	1 823,438	From 12 m. to 1 a. m	.08	1,107,427
From 11 a. m. to 12 m	.11	1,541,310	June 26—		
From 12 m. to 1 p. m	.12	1,679,756	From 1 a. m. to 2 a. m	.09	1,244,929
From 1 p. m. to 2 p. m	.10	1,398,464	From 2 a. m. to 3 a. m	.08	1,105,779
From 2 p. m. to 3 p. m	.12	1,676,557	From 3 a. m. to 4 a. m	.09	1,243,074
From 3 p. m. to 4 p. m	.13	1,814,300	From 4 a. m. to 5 a. m	.09	1,242,093
From 4 p. m. to 5 p. m	.11	1,533,578	From 5 a. m. to 6 a. m	.10	1,378,952
From 5 p. m. to 6 p. m	.11	1,532,111			
From 6 p. m. to 7 p. m	.12	1,669,722	Total	2.55	35,541,845
From 7 p. m. to 8 p. m	.11	1,529,045			

The outflow during twenty-four hours as measured in the latter part of June, for the past seventeen years, is as follows:

Year.	Gallons.	Year.	Gallons.	Year.	Gallons.
1874	17,554,848	1880	25,740,138	1886	25,542,476
1875	21,000,000	1881	26,525,991	1887	26,878,424
1876	24,177,797	1882	29,727,864	1888	29,115,774
1877	23,252,932	1883	24,314,715	1889	27,708,779
1878	24,885,945	1884	24,827,013	1890	35,541,845
1879	25,947,642	1885	25,219,194		

TABLE 2.—*Showing for each day in the year condition of water at Great Falls, receiving reservoir, and distributing reservoir, and height of water over dam at Great Falls.*

Day of month.	Condition of water.			Height of water over dam at Great Falls, feet.	Condition of water.			Height of water over dam at Great Falls, feet.	Condition of water.			Height of water over dam at Great Falls, feet.	Condition of water.			Height of water over dam at Great Falls, feet.
	Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, effluent gate-house.		Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, effluent gate-house.		Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, effluent gate-house.		Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, effluent gate-house.	
	July, 1889.				August, 1889.				September, 1889.				October, 1889.			
1	36	34	11	.80	4	3	36	2.00	36	36	36	1.00	10	36	36	1.60
2	12	12	14	1.00	3	4	22	2.40	36	36	36	1.00	8	36	36	1.50
3	16	5	12	1.00	3	6	17	2.40	36	36	36	1.00	2	36	36	1.40
4	2	7	10	1.40	5	7	20	1.80	36	36	36	1.00	18	36	36	1.50
5	3	8	9	1.50	7	14	20	1.60	36	36	36	1.00	22	36	36	1.40
6	4	9	8	1.50	7	25	22	1.50	36	36	36	1.00	28	36	36	1.30
7	3	11	7	1.30	8	20	21	1.50	36	36	36	1.00	36	36	36	1.30
8	6	12	6	1.00	10	30	21	1.50	36	36	36	1.40	36	36	36	1.30
9	19	12	6	1.00	13	36	25	1.50	36	36	36	1.40	36	36	36	1.20
10	28	22	6	.90	5	34	24	1.60	36	36	36	1.40	36	36	36	1.20
11	32	22	8	.80	10	9	15	1.40	36	36	36	1.40	36	36	36	1.20
12	36	36	12	.70	12	12	16	1.40	36	36	36	1.30	36	36	36	1.20
13	36	36	14	.70	20	20	18	1.30	36	36	36	1.20	36	36	36	1.10
14	3	36	19	1.00	30	15	20	1.10	36	36	36	1.20	36	36	.....	1.10
15	3	36	20	1.00	34	25	23	1.10	36	36	36	1.30	36	36	.....	1.40
16	6	20	20	.90	34	30	26	1.40	19	36	36	1.60	36	36	.....	1.40
17	9	7	7	1.00	5	34	27	1.20	3	36	36	1.90	30	36	.....	1.50
18	10	7	12	1.00	4	36	30	1.10	2	36	36	2.50	36	36	.....	1.40
19	15	10	9	.90	6	36	26	1.00	2	33	36	2.50	36	36	.....	1.40
20	15	17	12	.90	12	36	22	1.00	2	20	36	2.40	36	36	.....	1.40
21	25	20	14	.90	34	36	20	1.00	3	22	36	2.00	36	36	.....	1.40
22	30	20	17	.90	36	36	24	1.00	4	22	36	1.80	36	36	.....	1.40
23	36	24	23	.80	36	36	26	1.00	8	26	30	1.60	30	36	.....	1.49
24	36	30	30	1.00	36	36	30	1.00	21	30	27	1.50	8	30	.....	1.70
25	36	36	36	1.00	36	36	36	1.00	26	30	15	1.50	20	22	.....	1.70
26	36	36	36	1.00	36	36	36	1.00	30	33	27	1.50	12	27	.....	1.80
27	30	34	36	1.20	36	36	36	1.00	5	33	28	2.20	7	33	.....	2.30
28	36	25	36	1.10	36	36	36	1.00	4	30	30	2.20	1	25	.....	2.70
29	10	35	36	1.60	36	36	36	1.00	8	22	32	1.90	1	14	.....	3.40
30	6	35	36	1.40	36	36	36	1.00	12	36	36	1.70	1	12	.....	3.20
31	4	8	36	2.40	36	36	36	1.00	.....	.....	.....	.....	1	13	.....	2.50

	November, 1889.				December, 1889.				January, 1890.				February, 1890.			
1	3	16	.....	2.10	2	6	.....	3.00	36	36	.....	1.40	36	36	.....	1.10
2	4	19	.....	1.90	6	6	.....	2.00	36	34	.....	1.40	36	36	.....	1.20
3	6	25	.....	1.80	7	7	.....	1.90	36	36	.....	1.30	36	36	.....	1.30
4	6	27	.....	1.80	20	8	.....	1.80	36	36	.....	1.30	15	36	.....	1.40
5	8	30	.....	1.70	28	8	.....	1.70	36	36	.....	1.20	20	36	.....	1.50
6	12	30	.....	1.70	31	10	.....	1.70	36	36	.....	1.20	5	36	.....	2.60
7	22	20	.....	1.60	36	10	.....	1.60	36	36	.....	1.10	3	36	.....	2.30
8	26	26	.....	1.50	36	11	.....	1.60	36	36	.....	1.10	2	36	.....	2.00
9	32	30	.....	1.60	36	15	.....	1.60	36	36	.....	1.10	1	22	.....	2.30
10	3	35	.....	2.40	36	16	.....	1.60	36	36	.....	1.00	2	12	.....	2.00
11	2	24	.....	2.10	36	17	.....	1.60	36	36	.....	1.00	3	10	.....	2.00
12	2	27	.....	2.80	36	20	.....	1.60	26	36	.....	1.00	9	13	.....	.90
13	6	6	.....	2.40	36	21	.....	1.50	36	36	.....	1.00	14	13	.....	.80
14	1	4	.....	3.20	36	22	.....	1.50	36	36	.....	1.00	16	10	.....	.80
15	1	3	.....	3.80	36	22	.....	1.60	36	36	.....	1.00	2	9	.....	.00
16	2	3	.....	3.10	36	22	.....	1.60	36	36	.....	1.00	1	6	.....	1.80
17	4	4	.....	2.50	36	22	.....	1.60	36	36	.....	1.10	1	5	.....	2.80
18	9	3	.....	2.20	30	25	.....	1.60	8	36	.....	1.20	1	4	.....	2.30
19	1	3	.....	2.70	30	26	.....	1.60	11	36	.....	1.20	2	4	.....	2.00
20	1	4	.....	3.00	18	30	.....	1.70	9	36	.....	1.30	2	5	.....	2.10
21	1	5	.....	3.00	19	30	.....	1.70	9	36	.....	1.20	2	6	.....	2.00
22	1	5	.....	2.90	17	31	.....	1.60	15	36	.....	1.20	3	6	.....	2.70
23	2	4	.....	2.80	27	31	.....	1.60	16	36	.....	1.20	3	7	.....	2.40
24	5	6	.....	2.50	33	30	.....	1.50	30	36	.....	1.20	3	7	.....	2.10
25	7	7	.....	2.30	36	32	.....	1.50	36	36	.....	1.30	3	8	.....	2.00
26	14	7	.....	2.10	36	30	.....	1.50	36	36	.....	1.20	12	11	.....	1.90
27	14	8	.....	2.00	36	30	.....	1.50	36	36	.....	1.20	14	10	.....	1.80
28	8	11	.....	2.10	36	26	.....	1.40	36	36	.....	1.20	14	11	.....	1.80
29	1	9	.....	2.20	36	31	.....	1.40	36	36	.....	1.20	.....	.....	.....	.....
30	2	7	.....	2.40	36	32	.....	1.40	36	36	.....	1.20	.....	.....	.....	.....
31	.....	.....	.....	.....	36	32	.....	1.40	36	36	.....	1.10	.....	.....	.....	.....

TABLE 2.—*Showing for each day in the year condition of water at Great Falls, receiving reservoir, etc.*—Continued.

Day of month.	Condition of water.			Height of water over dam at Great Falls, feet.	Condition of water.			Height of water over dam at Great Falls, feet.	Condition of water.			Height of water over dam at Great Falls, feet.	Condition of water.			Height of water over dam at Great Falls, feet.
	Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, effluent gate-house.		Great Falls.	Receiving reservoir, south connection.	Distributing reservoir effluent gate-house.		Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, effluent gate-house.		Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, effluent gate-house.	
	March, 1890.				April, 1890.				May, 1890.				June, 1890.			
1	20	11	.....	1.90	14	26	.....	1.70	28	36	36	1.50	7	36	7	1.80
2	8	13	.....	1.80	30	26	12	1.60	28	36	36	1.50	19	36	7	1.70
3	8	12	.....	.70	36	29	14	1.50	29	36	36	1.40	6	36	9	1.80
4	16	13	.....	1.60	36	28	14	1.50	30	36	36	1.40	10	36	13	1.60
5	26	16	.....	1.50	3	29	23	1.80	33	36	36	1.40	17	36	14	1.50
6	36	16	.....	1.50	5	20	21	2.20	33	36	36	1.40	26	36	22	1.50
7	36	14	.....	1.50	5	21	16	2.30	14	36	36	1.60	22	36	26	1.50
8	36	14	.....	1.50	8	22	11	2.00	8	36	36	2.30	6	36	26	1.50
9	36	18	.....	1.50	10	23	9	1.80	6	36	36	2.10	8	36	33	1.50
10	36	18	.....	1.40	9	27	13	1.80	10	36	36	2.00	16	36	36	1.50
11	36	18	.....	1.40	10	30	16	1.80	10	36	36	2.00	27	36	36	1.40
12	36	19	.....	1.40	20	30	16	1.80	22	36	36	1.90	30	36	36	1.40
13	36	24	.....	1.40	25	31	17	1.70	29	36	36	1.80	34	36	36	1.50
14	30	25	.....	1.60	17	35	20	1.60	26	36	36	1.70	5	36	36	1.50
15	2	25	.....	1.90	27	36	21	1.50	6	36	36	1.70	3	36	36	1.40
16	2	24	.....	2.80	30	36	20	1.50	4	36	36	1.80	3	36	36	1.40
17	1	23	.....	2.70	33	36	21	1.40	4	36	36	1.80	3	36	25	1.40
18	2	23	.....	2.40	36	36	23	1.40	8	36	36	1.70	8	36	16	1.40
19	6	21	.....	2.30	36	36	30	1.40	12	36	36	1.60	12	36	18	1.40
20	6	20	.....	2.20	36	36	36	1.40	2	36	36	1.90	12	36	22	1.40
21	6	14	.....	2.30	36	36	36	1.40	1	36	36	2.30	10	36	18	1.60
22	9	28	.....	2.40	36	36	36	1.30	1	36	21	2.60	17	36	20	1.50
23	1	14	.....	3.10	36	36	36	1.30	3	36	9	2.30	2	36	27	1.50
24	1	8	.....	4.00	36	36	36	1.20	6	36	7	2.00	2	36	30	1.60
25	1	7	.....	3.10	36	36	36	1.20	3	36	7	2.00	2	36	23	1.70
26	2	9	.....	2.50	36	36	36	1.30	1	36	6	2.60	3	36	17	1.50
27	6	11	.....	2.20	36	36	36	1.40	1	36	6	4.70	3	36	12	1.40
28	9	12	.....	2.00	17	36	36	1.50	1	36	7	3.80	5	36	6	1.40
29	6	20	.....	1.90	5	36	36	1.70	1	36	7	2.90	7	36	9	1.30
30	8	22	.....	1.80	10	36	36	1.70	2	36	7	2.30	12	36	9	1.30
31	10	22	.....	1.70	.....	.....	.....	.....	4	36	7	2.00	.....	.....	.....	.....

TABLE 3.—*Showing number of days during the fiscal year* 1889–'90 *on which the water was clear or turbid at the places indicated.*

Place.	Clear.	Slightly turbid.	Turbid.	Very turbid.
Great Falls	159	27	57	122
Receiving reservoir	258	27	44	36
Distributing reservoir	124	29	26	16

NOTE 1.—In determining the condition of the water a metallic tube with glass ends is used. This is filled with water, and the distance at which a ball immersed in the water can be seen from one of the ends is noted. When it can be seen at a distance of from 22 to 36 inches, inclusive, it is considered clear; from 15 to 21 inches, slightly turbid; from 8 to 14 inches, turbid, and from 0 to 7 inches, very turbid.

NOTE 2.—The distributing reservoir was empty, and the water flowed directly from Great Falls to the auxiliary gate-house, and thence to the mains, from October 14, 1889, to April 1, 1890, inclusive, so that no record of the turbidity of the distributing reservoir was taken between these dates.

TABLE 4.—*Showing daily gauge-pressure, taken at office Washington Aqueduct at 9 o'clock a. m.*

Month.	Main.	1	2	3	4	5	6	7	5	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average.
1889.	*Inch.*																																
July	36	32	32	31	31	31	31	31.5	31	31	31	31	31	31	32	31	30	31	30	31	31	31.5	31	31	31	29.5	31	31.5	32	31	31	31.5	31.08
August	36	31.5	31.5	31	31	31	31	31	31	31.5	31.5	32	31.5	31	31	31	31.5	31	32	31	31	31	31	31	31	32	31	31	30.5	30	31	31	31.14
September	36	31.5	31	30.5	31	31	30	30.5	31.5	31	32	31	31	31	31	31	31	31	31	31	28	28	27	31	29	29	29	31	30.5	31	31	....	30.42
October	36	31	31	29.5	28.5	28.5	29.5	29.5	29	27.5	27.5	28	28.5	29.5	28	28	28	28.5	29	28	30	28	27.5	29	29	29	29	30.5	29	29	29.5	30.5	28.93
November	36	30.5	30.5	31	30.5	29.5	30	30	30	32	30.5	30	30.5	30	30	30	30	31	30	29.5	30	30	30	30.5	30.5	30.5	30	30	30.5	30	30	....	30.25
December	36	31	30	30	30	30	30	30	30.5	29.5	30	30	30	30	30	31	30	30	30	30	29.5	29.5	30.5	29	29.5	30.5	29.5	30	30	30.5	30	30	30.02
1890.																																	
January	36	30.5	30	29	30	30.5	29	30	29	30	30	30	30.5	30	30	30	30	30	30	28	26	29	29	29	28.5	29.5	29.5	30	29.5	30	30	30	29.56
February	36	30.5	31	30	30	30	30	30.5	31	31	31	30	30	31	31	31	31	30	30	30	31	31	31	31	30.5	30	30	30.5	30	....	....	....	30.50
March	30	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	(a)	30.5	37	37	38	38	37	38	38	37	38	38	38	37.04
	36	31	31.5	30	30	33	31	30	31	31	31	30	30	30	30	30	31	30	30	(a)	31	40	40	40	40	38	40	40	38	39	40	40	33.88
	48	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	(b)	38	37	38	38	37	38	38	39	39	38	40	38.18
April	30	38	38	38	41	38	38	38	38	38	38	38	38	40	38	38	40	40	40	40	38	36	39	39	40	40	39.5	40	40	40	40	....	38.98
	36	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	38	(a)	40	40	39	39	39	39	39	....	39.76
	48	39	39	39	38	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	38	....	38.93
May	30	40	40	40	38	38	39	39	40	40	40	40	38	38	36	38	37	36	37	37	38	38	38	38	38	38	38	38	38	38	37	37	38.22
	36	39	39	39	38	38	39	39	39	39	39	38	38	38	37	38	38	38	38	38	39	39	39	39	39	38	39	39	39	39	37	37	38.45
	48	38	38	38	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	40	40	40	40	40	40	40	40	40	40	39	39	39.22
June	30	37.5	37	37	36	36	37	66	38	36	36	36	36	36	37	37	37.5	36	37	35.5	36.5	36.5	39	37	35.5	36	34.5	35	35	35	35	....	36.32
	36	37.5	37	37	36	46	37	66	38	36	36	36	37	36	37	39	39	40	40	40	39	39	39	39	38	38	34.5	36	35	35	35	....	37.27
	48	39	39	39	39	39	40	39.5	40	40	39.5	39	40	40	40	39	39	39	39	40	39	39	39	39	39	39	39	39	39	39	39	....	39.27

b 48-inch main put in operation at 10.40 a. m.

a Making connections.

Table of pressures along the line of the 48-inch main, the water in the reservoir standing at 145 feet above datum, June 27, 1890.

Location.	Elevation of locality in feet.	Pressures.		Elevation of water above datum in feet.
		Lbs.	Feet.	
R and Fourth streets	76.0	27	62.3	138.3
R street and New Jersey avenue	77.0	27	62.3	139.3
R and Fifth streets	75.7	27⅛	63.5	139.2
R and Seventh streets	79.2	26½	61.2	140.4
R and Eighth streets	79.3	26	60.0	139.3
R and Ninth street	79.4	25½	58.8	138.2
R, Ninth, and Tenth streets	81.0	25½	58.8	139.8
R and Tenth streets	82.6	25	57.7	140.3
R and Eleventh streets	86.6	23½	54.2	140.8
R street and Vermont avenue	90.2	22	50.8	141.0
R and Thirteenth streets	96.2	18½	42.7	138.9
R and Fourteenth streets	102.0	16½	38.1	140.1
R and Fifteenth streets	91.7	21	48.5	140.2
R and Sixteenth streets	88.1	23	53.1	141.2
R and Seventeenth streets	86.5	25	57.7	144.2
New Hampshire avenue and Q street	86.4	23½	54.2	140.6
New Hampshire avenue and Dupont circle	88.4	23	53.1	141.5
New Hampshire avenue and N street	76.3	28	64.6	140.9
New Hampshire avenue and M street	60.2	36	83.1	143.3
M and Twenty-second streets	58.9	35	80.8	139.7
M and Twenty-third streets	61.4	33½	77.3	138.7
M and Twenty-fourth streets	63.7	33	76.2	139.9
M and Thirty-second streets	69.1	31½	72.8	141.9
M and Thirty-fourth streets	76.5	28½	65.8	142.3

Table of pressures along the line of the 36-inch main, the water in the reservoir standing at 146 feet above datum on February 27, 1890, and at 145 feet above datum on June 27, 1890.

Location.	February 27, 1890.				June 27, 1890.		
	Elevation of locality in feet.	Pressures.		Elevation of water above datum in feet.	Pressures.		Elevation of water above datum. in feet.
		Lbs.	Feet.		Lbs.	Feet.	
L and Twenty-fourth streets	65.8	24	55.4	120.2	28	64.6	130.4
L and Nineteenth streets	51.7	26	60.0	111.7	32½	75.0	126.7
L and Eighteenth streets	55.4	26	60.0	112.4	32	73.9	129.3
L and Seventh streets	72.9	17	39.2	112.1	23½	54.2	127.1
L and Fifth streets	62.9	20	46.1	109.0	31	71.6	134.5
L street and New Jersey avenue	49.8	26	60.0	109.8	30½	70.4	120.2

The pressures of February 27, 1890, were before the introduction of water into the 48-inch main.
The pressures of June 27, 1890, were after its introduction and after the division of the city into high and low service areas.

Table of pressures along the line of the 30-inch main, the water in the reservoir standing at 146 feet above datum on February 27, 1890, and at 145 feet above datum on June 27, 1890.

Location.	Elevation of locality in feet.	February 27, 1890. Pressures. Lbs.	Feet.	Elevation of water above datum in feet.	June 27, 1890. Pressures. Lbs.	Feet.	Elevation of water above datum in feet.
K and Twenty-fourth streets	64.3	20	46.2	110.5	26½	61.2	125.5
K and Twenty-second streets	65.7	19	44.0	109.7	27	62.3	128.0
K and Twenty-first streets*	57.3	25	57.7	115.0	32	73.9	131.2
K and Twentieth streets	61.7	21	48.5	110.2	30	69.3	131.0
K and Eighteenth streets*	67.2	21	48.5	115.7	27½	63.5	130.7
K and Connecticut avenue*	57.8	25	57.7	115.5	31	71.6	129.4
K and Seventeenth streets*	55.5	25	57.7	113.1	30	69.3	124.7
K and Sixteenth streets	53.8	22	50.8	104.6	31	71.6	125.4
K and Vermont avenue*	63.2	21	48.5	111.7	25½	58.8	122.0
K and Fourteenth streets*	63.4	21	48.5	111.9	24½	56.6	120.0
K and Thirteenth streets*	77.2	15	34.6	111.8	17½	40.4	117.6
K and Twelfth streets*	74.1	15	34.6	108.7	18½	42.7	116.8
K and Eleventh streets	67.8	13	30.0	97.8	20	46.2	114.0
K and Tenth streets	66.2	15	34.6	100.8	22½	51.5	117.7
K and Eighth streets	58.1	17	39.3	97.4	24	55.4	113.5
Massachusetts avenue and Sixth street	.....	.....	.....	.....	28	64.6	121.3
Massachusetts avenue and Fifth street	.....	.....	.....	.....	28½	65.8	118.2
Massachusetts avenue and Fourth street	.....	.....	.....	.....	30	69.3	118.5
Massachusetts avenue and Second street	.....	.....	.....	.....	31½	72.8	114.7

At localities marked (*) the water was supplied on February 27, 1890, to the hydrants from the 36-inch main on L street.

The observations June 27, 1890, were after the introduction of water into the 48-inch main and after the city had been divided into high and low service areas.

Table of pressures along East Capitol street before and after the introduction of water into the 48-inch main.

Localities.	Elevation of locality in feet.	Before the introduction of water into the 48-inch main, the water in the distributing reservoir standing at 146 feet above datum. Pressures. Lbs.	Feet.	Elevation of water above datum in feet.	At the end of the fiscal year ending June 30, 1890, the water in the distributing reservoir standing at 145 feet above datum. Pressures. Lbs.	Feet.	Elevation of water above datum in feet.
East Capitol and Second streets	93.0	4	9.2	102.2	15	24.6	127.6
East Capitol and Third streets	94.0	3½	8.1	102.1	15½	35.8	129.8
East Capitol and Fifth streets	88.5	6	13.9	102.4	16½	38.1	126.6
East Capitol and Sixth streets	86.2	6½	15.0	101.2	17½	40.4	126.6
East Capitol and Seventh streets	81.4	8	18.5	99.9	20	46.2	127.6
East Capitol and Ninth streets	83.8	8½	19.7	103.5	20	46.2	130.0
East Capitol and Eleventh streets	86.0	6½	15.0	101.0	18½	42.7	128.7

List of appropriations made for the Washington Aqueduct, with the dates of acts for the same.

Date.	Amount.	Date.	Amount.	Date.	Amount.
Sept. 30, 1850	$500	Mar. 3, 1869	$25,000	June 4, 1880 (*f*)	$20,000
Aug. 31, 1852 (*a*)	5,000	July 15, 1870 (*b*)	120,822	Mar. 3, 1881	20,000
Mar. 3, 1863	100,000	Mar. 3, 1871	114,196	July 1, 1882 (*g*)	20,000
Mar. 3, 1855	250,000	June 10, 1872	70,555	Mar. 3, 1883	20,000
Aug. 18, 1856	250,000	Jan. 23, 1873	14,000	July 5, 1884	20,000
Mar. 3, 1857	1,000,000	Mar. 3, 1873 (*c*)	43,600	Feb. 25, 1885	20,000
June 12, 1858	800,000	June 23, 1874 (*d*)	36,400	July 9, 1886	20,000
June 25, 1860	500,000	Mar. 3, 1875	26,000	Mar. 3, 1887	20,000
July 4, 1864	150,000	July 31, 1876	22,000	July 18, 1888 (*h*)	20,000
July 28, 1866	142.584	Mar. 3, 1877	15,000	Mar. 2, 1889 (*i*)	20,000
Dec. 20, 1866	12,000	June 20, 1878	15,000		
Mar. 2, 1867	20,000	Mar. 3, 1879 (*e*)	20,000	Total	4,005,157
July 25, 1868	52,500				

NOTE.—Reverted to the Treasury: (*a*) $2.81, (*b*) $46.25, (*c*) $560.87, (*d*) 35 cents, (*e*) $1,109.87, (*f*) $381.06 (*g*) $1,354.17, (*h*) $2,266.34, (*i*) $4.12; total, $5,725.84. This sum being deducted from the total amount appropriated shows the amount ($3,999,431.16) expended to June 30, 1890. Since 1878 one-half of the amounts appropriated have been contributed by the United States and the other half by the District of Columbia.

The following is a money statement for the fiscal year ending June 30, 1890:

July 1, 1889, amount available		$20,000.00
July 1, 1890, amount expended during fiscal year	$16,916.74	
July 1, 1890, outstanding liabilities	2,840.54	
July 1, 1890, amount covered by uncompleted contracts made during fiscal year ending June 30, 1890	238,60	
		19,995.88
July 1, 1890, amount to be covered into the United States Treasury		4.12

The estimates of appropriations that should be made for the year ending June 30, 1892, are as follows, and I urgently recommend that the provisions of law suggested in this report be attached to the next appropriations for the reasons stated:

For improving the receiving reservoir, including the purchase or condemnation of the necessary land	$284,625
For improving the distributing reservoir by lowering theheight of the cross-dam	12,500
For protecting the inlet to the aqueduct at Great Falls	5,000
For extending the outlet of waste weir No. 3	2,500
For purchase or condemnation of a site for a storage yard	7,500
For cleaning out the distributing reservoir	13,825
For maintenance and repairs of the aqueduct and the reservoirs, roads, etc., connected therewith	21,000
	346,950

An increase of $1,000 over the appropriation of former years for maintenance and repairs is made necessary by the increased amount that will be required by the addition of the 48-inch and the new 30-inch mains to the former system of supply.

A A A 2.

WATER SUPPLY, DISTRICT OF COLUMBIA.

THE 48-INCH MAIN.

By the act of Congress approved March 2, 1889, $575,000 was appropriated—

To enable the Secretary of War to cause to be constructed and put in operation a 48-inch cast-iron main from the present distributing reservoir above Georgetown easterly to Rock Creek at M street, and thence along M street to New Hampshire avenue; thence northeasterly along New Hampshire avenue to R street north; thence along R street to connect with the present 48-inch main from the new reservoir at R and Fourth streets, and to make the necessary connections and to provide the necessary apparatus for thereby specially supplying the present deficiencies of water at the higher levels of the city, and in general to increase the water supply. The said work shall be done under the direction of the Chief of Engineers, in the shortest practicable time.

Under the authority contained in the latter portion of the act, it was decided to do the following work in addition to the laying of the 48-inch main:

For the purpose of more efficient distribution of the water of the 48-inch main on Capitol Hill, to lay a 30-inch main from New Jersey avenue and B street across the Capitol Grounds to East Capitol and First street east, and thence along East Capitol street to Eleventh street east.

For the purpose of dividing the city into high and low service areas—the high-service area to be supplied by the 48-inch main and the low-service area by the old mains—to lay a 24-inch by-pass over the 30-inch main at New Jersey avenue and L street; to lay a 12-inch by-pass under the 30 inch main on New Jersey avenue, at Massachusetts avenue; to lay 6-inch by-passes under the 30-inch main on New Jersey avenue at E, F, G, and K streets; to place valves in the outlets northward from the 36-inch main in L street, at Massachusetts avenue, Eleventh, Twelfth, Thirteenth, and Nineteenth streets, and to place a 36-inch valve in the 36-inch main, just west of New Jersey avenue.

For the purpose of a better supply of the section of high land just east of New Jersey avenue, in the vicinity of M and N streets, to connect the distribution system of this section with the 48-inch main at New York avenue.

For the purpose of enabling the 36-inch and 30-inch mains to be re-enforced by the 48-inch main, and to re-enforce each other as required for the best supply of the low-service areas of the city to lay in Eighteenth street a 24-inch connecting main between the 36-inch main in L street and the 30-inch main in K street; to lay in M street, Georgetown, a 36 inch connection between the 48-inch and 36-inch mains, and a 30-inch connection between the 36-inch and 30-inch mains; to lay in the Canal road near Foundry Branch a 36-inch connection between the 48-inch and 36-inch mains; to make a connection between the 48 inch main and the 36-inch main in the gate-chamber at the distributing reservoir. Also to connect the 48-inch main with the auxiliary gate-house, the terminus of the 7-foot by-conduit which, when it is required, conveys the water from Great Falls around this reservoir directly to the mains. All of these connections were to be controlled by valves.

The result anticipated by the project is set forth in a letter from the Chief of Engineers to Hon. George F. Edmunds, United States Senate, dated February 19, 1889, which is printed in Senate Report No. 2686, Fiftieth Congress, second session, and it is, in brief, designed to afford

ample relief in respect of the water supply to Washington, until there will be required from 45,000,000 to 50,000,000 gallons per day, say for a period of from ten to fifteen years.

The object of placing the 48-inch main as far north as R street was to cut the long lines of the city's small service mains which fed up from the 36-inch main in L street, through the high northern portions of the city, and thus reduce the loss of head by friction which existed in these mains, and lessened their capacity of delivery.

At the commencement of the fiscal year contracts had been made by my predecessor for the materials, a small portion of which had been received, and for hauling it and for excavating the trenches as far west as the Arlington Bridge. I assumed charge of the work on the 17th of July, and commenced preparations for laying the mains by the construction of derricks, the purchase and fabrication of tools and implements, and the engagement of foremen for the different gangs of workmen required, so that as soon as sufficient quantities of the materials should be received the work could be energetically carried on.

On the 12th of August the first working force had been organized and the work commenced at the intersection of Fourth and R streets. Other parties were soon after at work on the Conduit road; at the distributing reservoir in excavating through the dam for the connection of the 48 inch main with the reservoir; on M street in Georgetown; on Capitol Hill, and on the Canal road.

With this organization the mains were laid as rapidly as the weather permitted.

The 30-inch main on Capitol Hill, with the exception of the curved Y connecting it with the old 30-inch main at New Jersey avenue and B street, was completed in January. The last pipe in the 48-inch main was laid on the Canal road on the 14th of March, and the main was completed ready for use, by the calking on the reservoir division of the last joint on the 18th.

The total number of working days, that is, excluding Sundays, holidays, and rainy days, occupied in laying the mains, was 149. The length of the 48 inch main is 22,888 feet, and of the 30 inch main on Capitol Hill 5,695 feet, a total of 28,583 feet, or about 5½ miles. The total weight of iron in the mains is about 20,225,000 pounds.

The great valves at both ends of the R street section were shut, and it was filled with water from the old mains on the 27th of February; the New Hampshire avenue section was filled on the 17th, the Conduit road section on the 18th, and the Georgetown section on the 19th of March. The filling of each section had driven the air from it through the air-valve provided at its summit, and the entire main was under static pressures (at the lower places on the line of nearly 50 pounds to the square inch), pressures greater by several pounds than it would be required to sustain when the water should be set in motion.

These pressures severely tested the work of Mr. Cunningham, my principal master calker, of the master calkers of the different gangs, and of the workmen, and to them is due the credit that not a leak from any of the more than 2,000 joints of the 48-inch main and the nearly 500 joints of the 30-inch main on Capitol Hill was discovered during this trial.

Early on the morning of the 20th of March all the great valves at the ends of the sections, excepting one between the Georgetown and the New Hampshire avenue sections were opened, and at 10.40 a. m. on that day this valve was slowly raised and the entire body of water, 2,149,000 gallons, was started in motion. At the same instant the new

pressure was transmitted to Capitol Hill, and the water commenced to rise everywhere in that section of the city. Captain Lusk, of the Engineers, assistant to the Engineer Commissioner of the District, who had kindly stationed himself with a pressure gauge at a fire-hydrant at the intersection of B and First streets east, observed that between 10^h 40^m and 12^h 40^m, during which the opening of the valve in Georgetown was fully completed, the pressures rose from 12 pounds per square inch to $22\frac{1}{2}$ pounds, corresponding to a rise of more than 24 feet in the water in that vicinity. Since then connection at New Jersey avenue and B street has been made, and the pressures on Capitol Hill have risen still more.

The pressures at numerous fire-hydrants along the line of the old and new mains were taken before the introduction of the new supply. These pressures reduced to feet and added to the elevations of the localities indicate, approximately, the heights to which water then rose in the service-pipes connected with the street mains that supply these pipes. The tables in my report of the Washington Aqueduct, give the results of these observations, together with the results of similar observations taken at the close of the fiscal year. It will be seen that while formerly the water in the service-pipes on East Capitol street on Capitol Hill rose to a height of from 100 to $103\frac{1}{2}$ feet above datum, the water in the distributing reservoir standing at 146 feet, it was found at the end of the fiscal year just passed, that it rose to a height of from $126\frac{1}{2}$ feet to 130 feet above datum, the water in the distributing reservoir standing at 145 feet above that plane, so that it may be stated in general terms that the water on Capitol Hill, excepting where its free flow is obstructed by the insufficient size or the internal corrosions of street mains and service-pipes, stands about 30 feet higher than before it had the new supply.

The benefit of the mains to the higher portions of northwest Washington, which were formerly supplied under pressures from the stand-pipe at the head of Sixteenth street on Meridian Hill, is shown by the fact that much better pressures are now obtained than were obtained from the stand-pipe, although the latter is much higher than the distributing reservoir itself. This is for the reason that the water from the pumps was delivered through very long lines of small street mains running south from U street and they are, many of them, obstructed by internal deposits, so that the loss of head by friction was enormous, amounting at many points to 42 feet in a distance of from 5,000 to 6,000 feet. Now, the length of these street mains is cut by the 48-inch main at R street, and they are fed north and south from R street, so that there is much less loss of head by friction in them.

The U-street Pumping Station formerly supplied a large area extending as far south as N street. Now they supply only the area north of Boundary street, and there is a great saving to the District government in cost of fuel and the other expenses of running the pumping engines.

Since the introduction of water by the 48-inch main, much work that remained has been done, as follows:

Connections have been made between the new mains and the old mains and between these mains, at New Jersey avenue and B street, at R and Seventeenth streets; at Eighteenth and K streets; at Eighteenth and L streets; on M street, Georgetown, between Twenty-ninth and Thirtieth streets; near Foundry Branch; in the gate-chamber at the distributing reservoir, and between the 48-inch main and the auxiliary gate-house at the reservoir; the connections between the new mains and the city mains at each street intersection have been made,

except a few which were made before the water was turned into the new mains; the city has been divided into high and low service areas by the construction of six by-passes under and over the old 30-inch main on New Jersey avenue and by the insertion into the city's mains of the required valves along the line of the 36-inch main in L street; eleven masonry gate-chambers have been constructed below the levels of the streets and roads along the routes of the mains; a 12-inch blow-off has been inserted in the old 30-inch main at New Jersey avenue and D street, and a 36-inch valve has been placed in the 36-inch main at New Jersey avenue and L street; strong culverts under the Conduit road passing either over or under the 48-inch main, with substantial retaining walls at their ends, have been built; the masonry of the abutments of M street bridge over Rock Creek, removed for preparing the seats of the new iron bridge for the 48-inch main, has been replaced; the extension, 40 feet long, of the old gate chamber at the distributing reservoir has been completed, and the earth-work of the dam has been carefully replaced and sodded; the fences along the Conduit and Canal roads which it was necessary to remove in laying the 48-inch main have been rebuilt, and the asphalt and granite-block pavements in the city, and the macadam pavements in the country that were removed for the excavation of the trenches, have been replaced, so that all vestiges of the routes of the mains have been removed.

The only work connected with the original project remaining to be done is the filling in the trench over the connection of the 48-inch main with the auxiliary gate house at the reservoir; the construction of the masonry well for the stop timbers required for controlling the motion of the water through this connection; the completion of the laying of new service mains in M street, Georgetown, between Twenty-eighth and Thirtieth streets, to enable the service pipes connected with the 12-inch main and the 30 inch main, which endangered the foundations of the 48-inch main, to be cut off; and the rebuilding on the Canal road of a portion of the wall of the Chesapeake and Ohio Canal, which fell under the weight of the pipes of the 48-inch main deposited on the side of the road before they were laid in the trench.

The first two works have been postponed until July for economical considerations. The last will be done on the first occasion that the water is lowered for repairs to the Georgetown level of the canal.

A special lowering of the water to enable me to rebuild the wall would result in a heavy daily loss to the millers of Georgetown, who have purchased the right of using the water for running their mills.

East of Rock Creek but little difficulty (other than the meeting of a buried stone bridge that formerly crossed Tiber Creek at Seventh and R streets and some hard rock on M street between Twenty-fourth and Twenty-sixth streets) was encountered in excavating the trenches or in laying the mains. Near the former place and between Seventeenth street and New Hampshire avenue on R street, where the line ran through the bed of an old pond, the ground was so soft that I deemed it expedient to excavate the trench to a greater depth and support the main on a thick bed of concrete.

West of Rock Creek the work was not so easy. In M street, Georgetown, there was a sewer on each side of the street, and there had been previously laid in this street a 36-inch, a 30-inch, and a 12-inch water main, an electric conduit, and the principal gas main for supplying that section of the city.

There was also much rock in this portion of the route. Through this net-work of obstacles the most practicable line for the 48-inch main was

very near the north curb of the street, and in order to prevent the closing of business houses by the excavated earth, it became necessary to construct temporary bulkheads of timbers for holding it, leaving a narrow passage-way for pedestrians between the bulkhead and the building line.

The trench for the 48-inch main was necessarily of such large dimensions and the amount of excavated earth was so great that it not only covered the sidewalks, but sometimes the parking up to the doors of the shops and houses, so that much discomfort was experienced by citizens in all the city portions of the routes selected by Congress, but almost without exception they showed a gratifying patience and a willingness to suffer temporarily for the sake of the public benefit expected from the main.

On the Canal road, a short distance west of Arlington Bridge, and also between College Pond and Foundry Branch, a great deal of rock was encountered. The latter portion, most of it, was exceedingly hard, and the road, which is narrow and has the Chesapeake and Ohio Canal on one side and a steep rocky bluff on the other, was already occupied by the old mains. The only place left available for the 48-inch main, which is 4 feet 10 inches in diameter at the bell ends of the pipes, was between the 36-inch and 30 inch mains, and the space between them, everywhere narrow, was filled with solid rock. At one place this space was only 6 feet 9 inches wide, and the operation of blasting out this rock within a few inches of the old mains running full of water under 100 feet of pressure was a delicate one. It was successfully accomplished by the interposition of as many thicknesses of boards as possible between the old mains and the rock, and these cushions of wood so effectually prevented the shocks of the blasts of the dynamite from reaching the mains, that not even a leak in the joints was discovered.

On the Conduit road the work of laying the main was especially interfered with by the fall rains, which greatly retarded it everywhere along the line. In November we lost about half the month, but fortunately the winter was exceptionally favorable, and we probably about made up the time lost in the fall.

In the country portions of the route we had more difficulty whenever it rained than in the paved streets of the city, for the reason that the clayey banks were constantly caving in, so that there was much extra handling of earth to be done as well as pumping out of water from the trench.

The softened banks and slippery mud in the trench and on its sides, where the legs of the derricks rested, added much to the difficulty, the cost, and the danger to the lives of the workmen of handling the sections of the pipe, which weighed between 4 and 5 tons each, and the valves, which weighed more than 8 tons each. We had many accidents during the progress of the work, but none with fatal results except in one instance, when, by the fall of a derrick while lifting a pipe on the Canal road, one of the workmen was killed.

One of the most important questions to be decided in commencing the work was the best means of carrying the 48-inch main over the streams that crossed its route, viz: Rock Creek, College Pond Creek, and Foundry Branch. I found that the arch of the highway bridge over the latter was low enough to allow the main to cross it without raising the level of the road-way; that the main could be laid over the arch of the bridge across College Pond Creek by raising the surface of the road at that point about 3 feet, and that the abutments of the M street highway bridge over Rock Creek were abundantly strong enough

to allow of the construction of a bridge for carrying the main under the north sidewalk. A contract was therefore made with the Phœnix Bridge Company of Pennsylvania for erecting a wrought-iron rivetted girder bridge, which was successfully and promptly completed.

It is a very substantial structure and is quite independent of the superstructure of the highway bridge, which it does not touch at any point.

In order to connect the 48-inch main with the distributing reservoir, it was necessary to excavate to a depth of 30 feet through the dam to the old gate-chamber. The dam was of course of "made" ground. Exterior to it was a large mass of loose rock which had been deposited from the tunnel-shaft, and this rested on a bed of clay, which, when cut by the trench and saturated with water, as it always was from springs, would constantly flow through the crevasses in the timbering and cause caving of the banks in spite of all the precautions that could be taken to guard against it.

It was originally intended to place all of the gates at the distributing reservoir connected with the new 48-inch main in the old gate-chamber, but it was already crowded with the gates and connections of the old mains. While the extension of this gate-chamber to serve as a protection to the mains in their passage through the dam was in progress my assistant, Captain Townsend, ingeniously conceived the plan, which I adopted, of making use of it by placing in it these gates and the heavy castings connected with them.

The 48-inch connection between the 48-inch main and the auxiliary gate-house passes through the side of this extension. It is 213 feet long, about 29 feet below the surface of the ground, and is mostly made up of curved pipes. It passes through the concrete foundation of the conduit constructed for conveying water from the reservoir to the shaft of the tunnel, and through the side wall of the auxiliary gate-house at a depth of 16½ feet below the surface of the water in this gate-house. It is designed to supply the 48-inch main and the 36-inch main when the water of the reservoir is shut off from the mains, leaving the 30-inch main and the 12-inch main which supplies the high-service reservoir in Georgetown to be supplied by the old 30-inch connection leading from the auxiliary gate-house into the old gate-chamber.

The line of the 48-inch main is divided by valves into sections of about an average length of 1 mile each, so that at any time, in case of a break in the main or of making connections, it will be necessary to empty but a portion of the main. These valves are at Fourth and R streets; on R street between Seventeenth street and New Hampshire avenue; on M street, Georgetown, between Twenty-ninth and Thirtieth streets; on the Canal road a little east of Foundry Branch, and at the reservoir. The valves in Georgetown and at Foundry Branch are so arranged that the water of the 48-inch main can be turned when necessary into the old mains and the high levels of the city can still be supplied with water, although under reduced pressures. The valves in the cross connection in Georgetown will allow the pressures in the different mains to be regulated to suit the variations in consumption of water that may be expected to occur in different sections of the city.

All the 48-inch valves as well as the valves controlling the connections between the 48-inch main and the old mains and between the old mains themselves are in masonry chambers specially constructed for the purpose. The six large valves in M street, Georgetown, required three of these chambers which underlie nearly the entire width of the street.

All of these chambers are covered by heavy arches, and access to them is had by man-holes through the surfaces of the streets and roads.

Similar chambers have been constructed for the 36-inch, 30-inch, and 24-inch valves that have been placed in New Jersey avenue, and for the 24-inch valve in Eighteenth street near K street.

The new mains are exceedingly well provided with large blow-offs, air-valves, and vacuum-valves to be used in emptying and filling the mains; also with small constant air-valves at the high points on the lines for discharging the air that is carried along in the water to these points where, unless gotten rid of, it would collect in such quantities as to obstruct the flow of the water.

A list of the blow-offs, vacuum-valves, and air-valves will be found in the accompanying tables.

Soon after commencing to lay the 48-inch main in R street at Fourth street, it occurred to me to suggest the insertion of a 48-inch by 48-inch Y at Rhode Island avenue, with the view of partially supplying the new reservoir near Howard University, which is at the same height as the distributing reservoir, through a 48-inch branch in that avenue, if it should be deemed advisable at any time to do so.

You approved the suggestion, the Y was inserted in the main and the outlet was closed by a 48-inch valve.

The cost of laying the 48-inch, the 30-inch, and 24-inch mains where there was no rock excavation, including the cost of the pipe, the excavation of the trenches, and the back filling was about $11.30, $5.03, and $3.93, respectively, per running foot. These amounts do not include the cost of the valves; the special castings (of which about 1,200,000 pounds were required), the masonry gate-chambers along the line and at the reservoir; the concrete foundations for the main; the connections with the old mains and between these mains; the machinery and tools; the earth and masonry work at the reservoir required for making connection with it; the by-passes on New Jersey avenue; the connections with the city's street mains, the Rock Creek bridge, or the repavement of the streets and roads.

In providing for doubling the delivery to the street mains of the city's distribution system, by the laying of the 48-inch main, the United States has furnished an abundant supply for all the uses of the Government and of citizens, with a large allowance for wastage for many years to come, and if there is in any portion of the city any lack of water or of pressure, it is due to defects either in the street mains or in the service pipes connecting these mains with houses.

Most of the street mains were laid many years ago when the population was small and much more compact than now. They are quite too small in diameter for the long extensions that have been made to them as the city expanded, and many of them are greatly obstructed by internal corrosions.

In many cases by reason of false economy on the part of owners of buildings, in others by reason of fraud on the part of contracting builders, the service pipes are not only not one-half the diameter they should have, but they are of ungalvanized iron, the rusting of which quickly diminishes the flow.

There is no complete remedy for the deficiency in the city's distribution system, except the taking up by the city of the small street mains in the thickly populated sections, and the laying of larger ones in their places, using the old pipes as they may be required, in extending the water supply to the outskirts of the city, but this will be very expensive and it can only be done gradually.

In the high area in the vicinity of M, N, and O streets between Tenth and Thirteenth streets, which is, a part of it, higher than Capitol Hill, there is still so much loss of head by reason of the small size and the bad condition of the street mains, that you have recently authorized me to use a portion of the remainder of the appropriation, in laying in Eleventh street a 24-inch connecting main between the 48-inch main in R street and the 36-inch and 30-inch mains in L street and K street, extending it northward from R street to U street, for the purpose of connecting with the city's 12-inch main in U street. The valves to be placed on the 24-inch main north of the 36-inch main are to be kept closed, except in case of fire or any other unusual draught on the 36-inch and 30-inch mains.

This will so much reduce the loss of head from friction that it is anticipated that the water will rise in the service pipes in the area referred to from 12 to 15 feet higher than it now rises.

For a similar reason and looking to the future of Capitol Hill, which is rapidly increasing in population, and from which the more rapidly increasing population of northwest Washington, will diminish more and more the supply from the new 48-inch main, you have also authorized me to lay a 30-inch main in New Jersey avenue from L street to B street. This main will be laid parallel to the old 30-inch main in New Jersey avenue. It will connect at L street with the 48-inch main and at B street with the new 30-inch main which extends east on Capitol Hill through the Capitol Grounds and East Capitol street to Eleventh street east.

Plans, specifications, and drawings have been prepared for these works and proposals have been invited for the materials and for such parts of the work as will not be done by days' labor.

Abstract of proposals for the construction of an aqueduct bridge over Rock Creek for water supply, District of Columbia, received in response to advertisement dated September 23, 1889, and opened October 7, 1889, by Lieut. Col. George H. Elliot, Corps of Engineers, U. S. A.

1. The Phœnix Bridge Co., of Phœnixville, Pa..... $5,850.00

Abstract of proposals for screen work at distributing reservoir for Washington aqueduct, received in response to circular letter dated May 28, 1890, and opened June 10, 1890, by Lieut. Col. George H. Elliot, Corps of Engineers, U. S. A.

1. Edward L. Dent, of Washington, D. C..... $1,320.50
2. Kinsinger & Divine, of Washington, D. C..... 1,600.00
3. Pettit & Dripps, of Washington, D. C..... 2,328.50

I am much indebted to Captain Townsend, Corps of Engineers, for assistance in office; to Mr. Simon Newton, chief clerk, for his untiring labor in the preparation of the accounts of my heavy disbursements during the year, and to my other office employés and numerous foremen for their faithful service; also to Mr. Fitzgerald, of the District office, for his enthusiastic and efficient services in making connections between the new mains and the city's street mains.

List of blow-offs, air-valves, constant air-valves, and vacuum-valves on the 48-inch and new 30-inch mains.

Location.	Size.
48-inch line.	*Inches.*
Blow-offs:	
R street between Fifth and Sixth streets	20
R street at Seventeenth street	20
Rock Creek Bridge	20
Foundry Branch	20
M street, Georgetown, 9 feet west of east curb of Thirty-third street	6
New Hampshire avenue and M street	3
Canal Road, 131 feet east of College Pond Bridge	3
Air-valves:	
R street at Fourteenth street	6
New Hampshire avenue, 58 feet north of Dupont Circle	6
M street at Twenty-fourth street	6
M street at Thirty-second street	6
M street at Thirty-fourth street	6
College Pond Bridge	6
Conduit Road, 300 feet east of the distributing reservoirs	6
*30-inch line.**	
Blow-offs:	
East Capitol and Seventh streets	12
New Jersey avenue and D street	12
Air-valve:	
East Capitol street, 59 feet east of east curb of Third street	4

* Small air-valves were also placed at the summits of the 24-inch by-pass at New Jersey avenue and L street, and the 24-inch connection on Eighteenth street between the 36-inch main in L street and the 30-inch main in K street.

No.	Size.	Location of vacuum-valves.	Location of constant air-valves.
	Inches.	*48-inch line.*	
2	3	R street at Fourteenth street	R street at Fourteenth street
2	3	New Hampshire avenue, 58 feet north of Dupont Circle.	New Hampshire avenue, 58 feet north of Dupont Circle.
2	3	M street at Twenty-fourth street	M street at Twenty-fourth street
2	3	M street at Thirty-second street	M street at Thirty-second street
2	3	M street at Thirty-fourth street	M street at Thirty-fourth street
			College Pond Bridge
			Canal road, 300 feet east of the distributing reservoir.
		30-inch line.	
1	3	East Capitol street, 59 feet east of east curb of Third street.	East Capitol street, 59 feet east of the east curb of Third street.

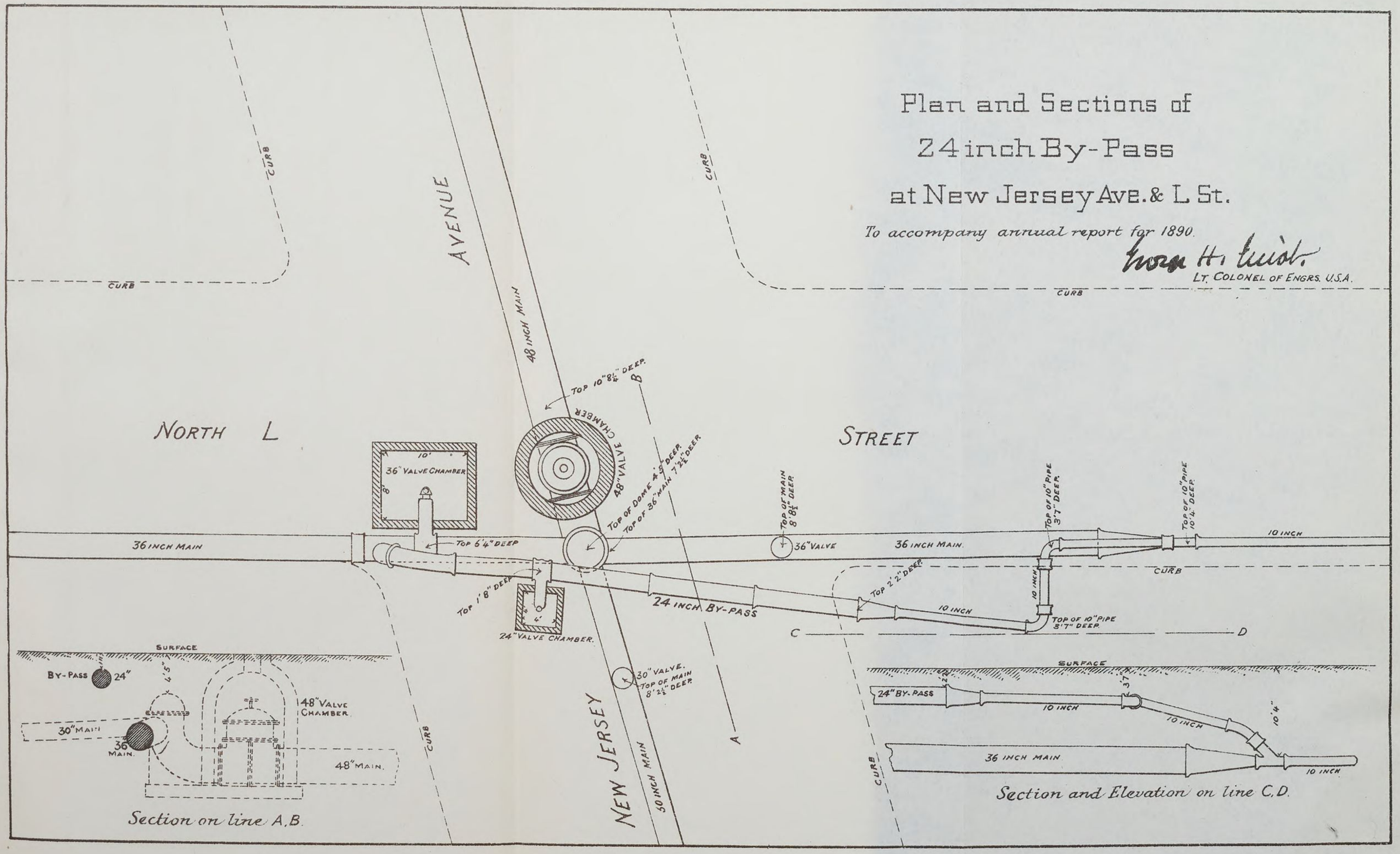
List of the 48-inch and other large valves placed in the new mains and connections.

Location.	No.
48-inch valves.	
R street at Fourth street	1
R street at Rhode Island avenue	1
R street between Seventeenth street and New Hampshire avenue	1
M street between Twenty-ninth and Thirtieth streets	2
Canal road near Foundry Branch	1
Gate chamber at the distributing reservoir	2
36-inch valves.	
L street at New Jersey avenue	1
M street between Twenty-ninth and Thirtieth streets	2
36-inch valves—Continued.	
Canal road near Foundry Branch	1
30-inch valves.	
New Jersey avenue at B street	2
M street between Twenty-ninth and Thirtieth streets	2
Gate-chamber at distributing reservoir	1
24-inch valves.	
New Jersey avenue at L street	1
Eighteenth street north of K street	1

Plan and Sections of
24 inch By-Pass
at New Jersey Ave. & L St.

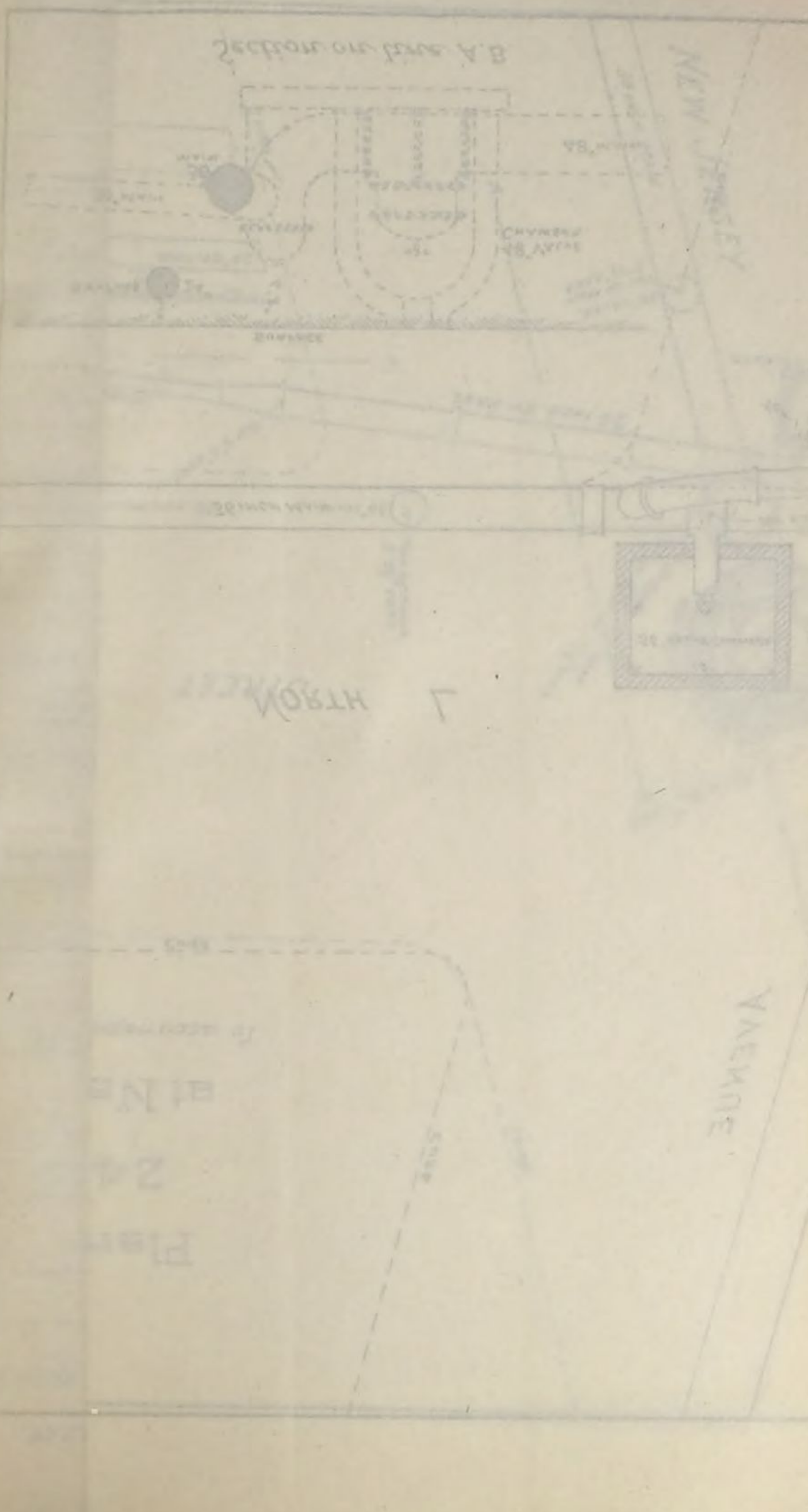
To accompany annual report for 1890.

Thos H. Handbook
LT. COLONEL OF ENGRS. U.S.A.

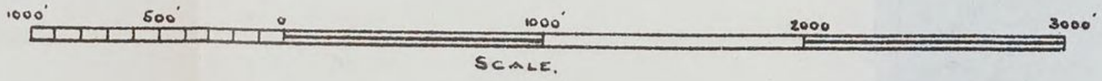


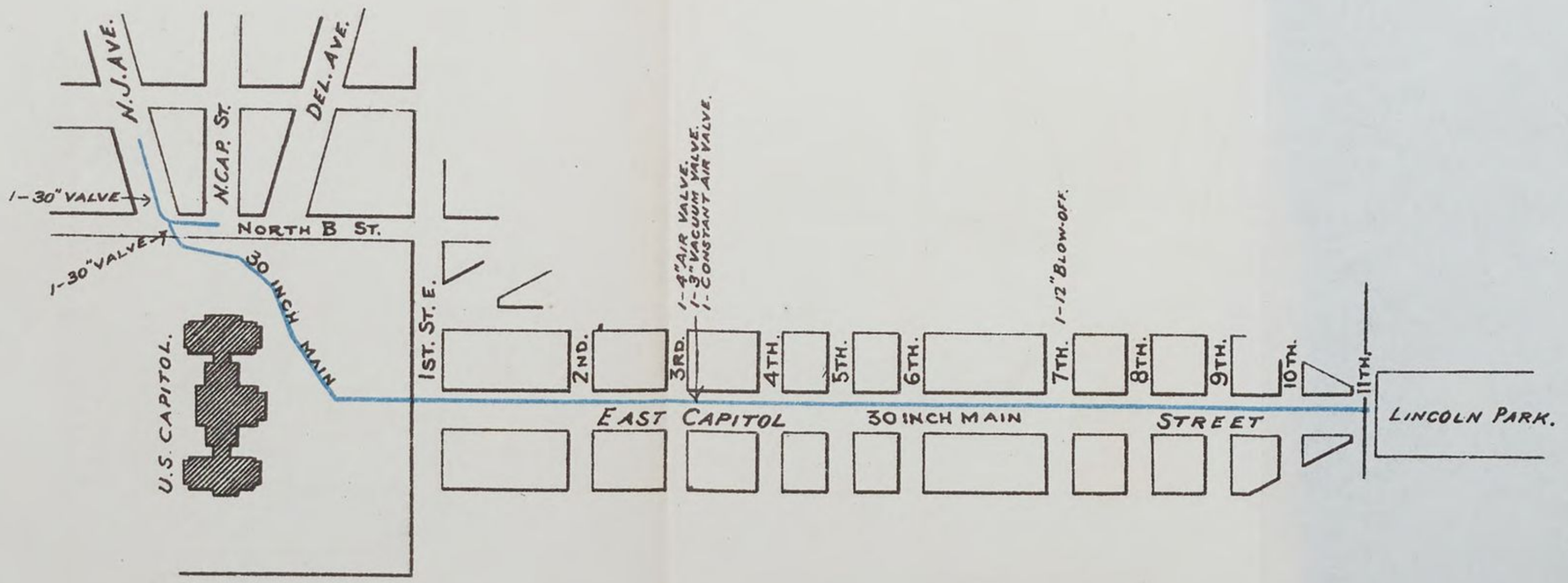
Section on line A.B.

Section and Elevation on line C.D.



Route of the new 30 inch Main.

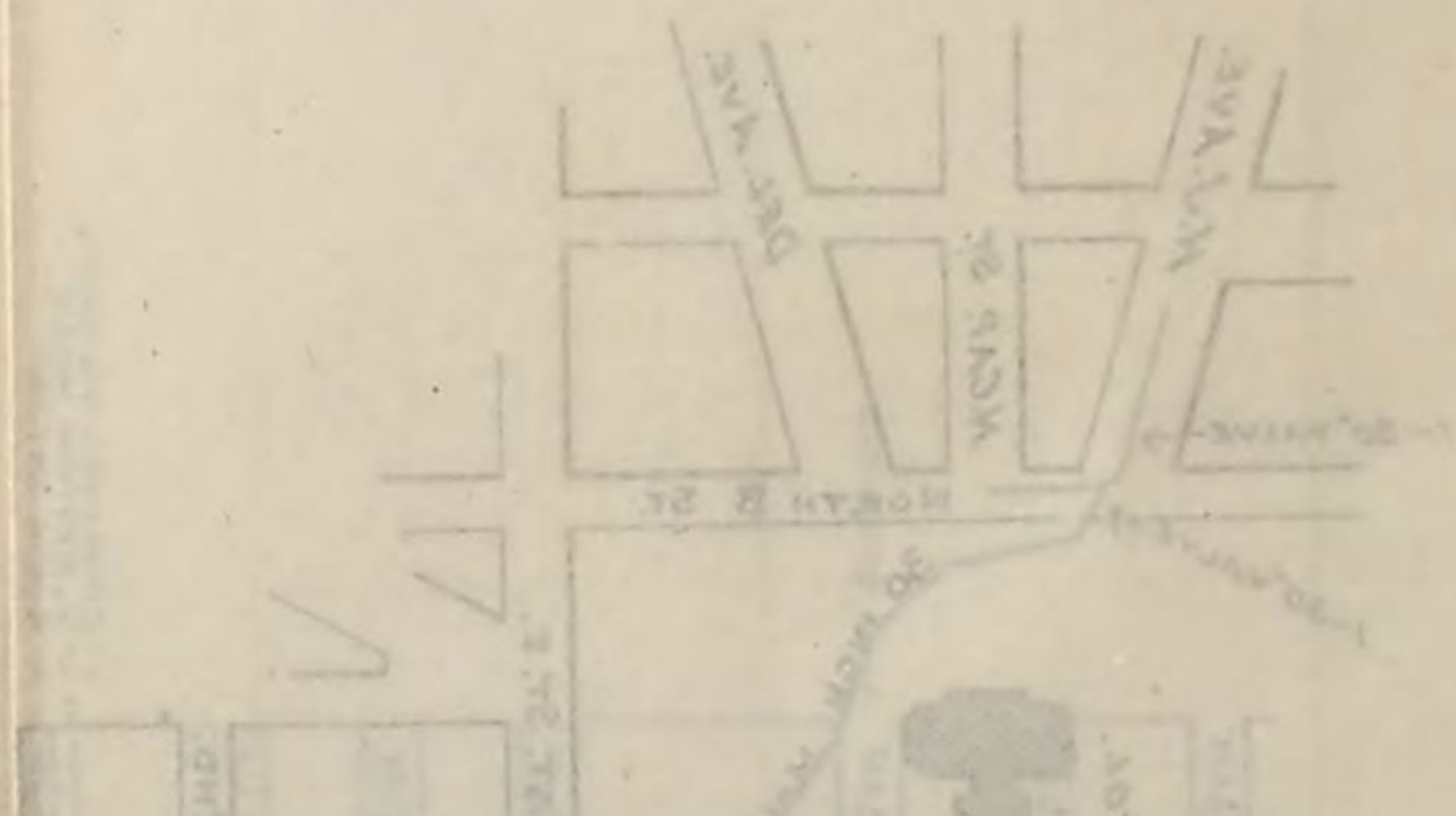




To accompany annual report for 1890.

Thos H. Symington

Lt. Colonel of Engrs. U.S.A.



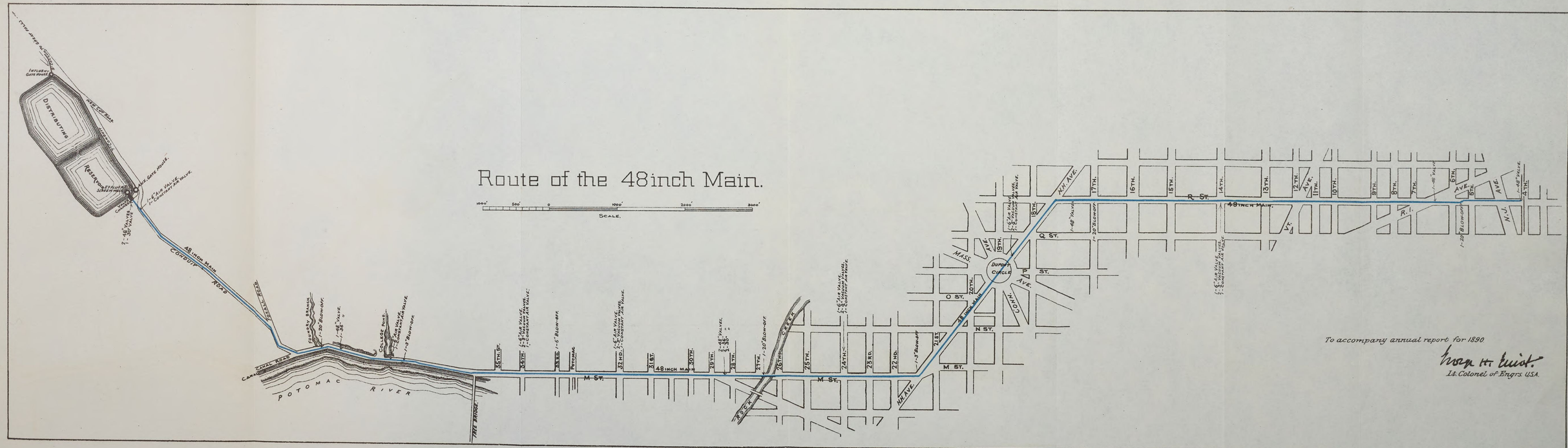

Route of the 48inch Main.
SCALE.
DISTRIBUTING RESERVOIR
INFLUENT GATE HOUSE
EFFLUENT GATE HOUSE
48 INCH MAIN CONDUIT
CANAL ROAD
POTOMAC RIVER
ARLINGTON MEMORIAL BRIDGE
M ST.
N ST.
O ST.
P ST.
Q ST.
R ST.
48 INCH MAIN
DUPONT CIRCLE
MASS. AVE.
N.H. AVE.
CONN. AVE.
R.I. AVE.
N.J. AVE.
To accompany annual report for 1890
Geo. H. Elliot
Lt. Colonel of Engrs. U.S.A.



Table showing the thickness of pipes used in the 48-inch and 30-inch mains, and in the connections; the weights per section and the permitted deviation from these weights.

Inside diameter.	Thickness.	Weight per 12-foot section.	Permitted deviations.
Inches.	*Inches.*	*Pounds.*	*Per cent.*
48	1.5	9,236	2½
36	1.22	5,494	2½
30	1.06	4,032	3
24	0.92	2,796	3
20	0.82	2,076	3

The money statement for the fiscal year ending June 30, 1890, is as follows:

July 1, 1889, amount available		$303,158.78
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$177,771.13	
July 1, 1890, outstanding liabilities	3,995.05	
July 1, 1890, amount covered by uncompleted contracts made during the fiscal year ending June 30, 1890	1,081.90	
		182,848.08
July 1, 1890, balance available		120,310.70

The amount stated above as expended during fiscal year, $177,771.13, does not show my actual expenditures for the year. To this amount should be added the sums of $13,449.73 and $256,639.79 referred to in the money statement for the last fiscal year as amount of "outstanding liabilities" and amount "covered by existing contracts," making for the amount actually expended during the year $447,860.65.

No estimate for further appropriation is submitted.

A A A 3.

INCREASING THE WATER SUPPLY OF WASHINGTON, DISTRICT OF COLUMBIA.

This work was commenced under an appropriation made in the act of Congress approved July 15, 1882.

The plan consisted of raising the dam in the Maryland channel at the Great Falls of the Potomac to an elevation of 148 feet above mean tide at the Washington navy-yard, and its extension at that height across Conn's Island and the Virginia channel of the river; extending the Washington Aqueduct from the distributing reservoir above Georgetown to the site selected for the new reservoir near Howard University by a tunnel 20,696.3 feet long; constructing at the tunnel outlet a new reservoir of about 300,000,000 gallons capacity, and connecting this reservoir by a new line of large mains with the existing system of water mains in the city of Washington.

All operations on this project are suspended, and no work has been done during the year.

In July an assistant engineer was employed by my predecessor in preparing maps, cross-sections, etc., of the new reservoir, and determining quantities excavated, to comply with a request of the Court of Claims for data in connection with the claim of the contractors against the United States.

In January two men were employed in excavating for measuring the outflow of water from the tunnel at Rock Creek.

A watchman has been employed during the year at the new reservoir.

The following is a list of appropriations for this work, with date of act for the same:

July 15, 1882	$1,485,279.30
July 7, 1884	87,500.00
March 3, 1885	87,500.00
March 26, 1886	5,000.00
August 4, 1886	555,000.00
March 30, 1886	355,000.00
Total	2,575,279.30

The following is a money statement for the fiscal year ending June 30, 1890:

Title of appropriation.	Amount unexpended July 1, 1889.	Expended during fiscal year.	Amount unexpended July 1, 1890.	Balance available July 1, 1890.
Land to extend aqueduct	$24,930.49	.....	$24,930.49	$24,930.49
Extension of aqueduct	276,241.24	$12.15	276,229.09	276,229.09
Main connections	1,989.18	.....	1,989.18	1,989.18
Land for reservoir	*173.09	.....	173.09	173.09
Constructing reservoir and gate-house	84,247.35	508.22	83,739.13	83,739.13
Water rights and land to extend dam at Great Falls	44,882.04	.....	44,882.04	44,882.04
Completion and extension of dam at Great Falls	4,665.52	.....	4,665.52	4,665.52
Aggregate	437,128.91	520.37	436,608.54	436,608.54

*This amount was stated in last annual report as $784.33, the difference ($611.24) being the sum referred to in that report as disbursed directly from the United States Treasury Department for advertising, which has since been charged to this appropriation.

No estimate for further appropriation is submitted.

A A A 4.

ERECTION OF FISH-WAYS AT GREAT FALLS.

Plans and specifications for a new system of fish-ways are being prepared under the supervision of the Commissioner of Fish and Fisheries.

By direction of the Secretary of War, the construction will be carried on under the direction of the Commissioner above mentioned, the engineer in charge being held responsible only for the proper protection of the dam at the Great Falls and for the disbursement of the funds appropriated.

No work has been in progress upon the fish-ways during the year.

The only expenditure was for a draughtsman employed in the office of the Commissioner of Fish and Fisheries in July, 1889, for four days.

The appropriations for this work to date, are as follows:

Act of July 15, 1882	$50,000.00
Act of February 1, 1888	25,000.00
Total	75,000.00
Total disbursements to June 30, 1890	44,979.68
Balance available	30,020.32

The money statement for the fiscal year ending June 30, 1890, is as follows:

July 1, 1889, amount available	$30,044.32
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	24.00
July 1, 1890, balance available	30,020.32

No estimate for further appropriation is submitted.

APPENDIX B B B.

IMPROVEMENT AND CARE OF PUBLIC BUILDINGS AND GROUNDS IN THE DISTRICT OF COLUMBIA—WASHINGTON MONUMENT.

REPORT OF COLONEL OSWALD H. ERNST, U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

OFFICE OF PUBLIC BUILDINGS AND GROUNDS,
Washington D. C., July 10, 1890.

GENERAL: In submitting the following annual report of operations upon public buildings and grounds under the charge of this office during the fiscal year ending June 30, 1890, I have the honor to state that I relieved Col. John M. Wilson, U. S. A., of the charge of these works on September 7, 1889, in obedience to Special Orders, No. 208, Adjutant-General's Office, September 7, 1889, paragraph 1, and General Orders, No. 7, Headquarters Corps of Engineers, U. S. Army, September 7, 1889:

GROUNDS NORTH OF EXECUTIVE MANSION.

Extensive repairs were made to the stone sidewalks leading from the north front gates to the front door of the mansion; wherever the flag-stones had settled they were taken up and relaid, and those found broken and unserviceable, thirty-five in all, were removed and replaced with new. The asphalt foot-walks on the east and west sides of the grounds, covering an area of 632 square yards, were entirely reconstructed, and the asphalt roadway leading from the main roadway down to the greenhouses, containing an area of 803 square yards, was resurfaced. The lawns were regularly mown during the growing season, and in the winter were covered with good compost, which was raked in during the spring. Flower-beds were prepared and stocked with plants and bulbs during the proper seasons, and the grounds maintained in a neat and cleanly condition.

GROUNDS SOUTH OF EXECUTIVE MANSION.

The roadways and walks in these grounds, where worn down by constant travel over them, were resurfaced with good binding gravel and thoroughly rolled, 160 cubic yards of unscreened gravel being used on the roadways and 190 cubic yards of screened gravel upon the foot-walks. Trees and shrubs were pruned, lawns frequently mown, and gutters and drain-traps maintained in a cleanly and serviceable condition. The old wooden stable belonging to the public

grounds, which for many years has been located at the northwest corner of the park fronting on Seventeenth street, was torn down and the ground occupied by it filled in and graded to conform to the surrounding park surfaces. The stable was rebuilt in the rear of the President's stable, and within the grove of trees which serves as a screen on the north, east and south sides of the latter building. All of the material from the old stable which was of any service was utilized in constructing the new building; water and gas pipes were laid for its service and a short gravel road constructed connecting it with the main roadway running out to Seventeenth and E streets. An iron post-and-pipe-rail fence was erected on the side of this new roadway where it passes the entrance to the cellar of the President's stable. An old wooden box-drain in this section of the park which had become unserviceable, was taken up and replaced with 406 feet of 8 inch and 30 feet of 6-inch new terra-cotta pipe, connected with the 12-inch main drain on this side of the park. Four brick drain-traps were also constructed and connected with the new drain.

The 50-foot roadway between the Executive Mansion and the State, War, and Navy Departments Building, known as West Executive avenue, was resurfaced with a heavy coating of good binding gravel, thoroughly rolled, 337 cubic yards of material being used in the work. The two old wooden foot-walks across this roadway were removed and replaced with substantial walks, each consisting of three rows of blue-stone flagging with a cobble-stone pavement laid between them, and iron covers were set in position over the gutters at each end of the cross-walks. Portions of the flagged pavement on the east side of this roadway having settled out of place, they were taken up and relaid, and wherever the curbing was out of line it was reset.

Seven high iron posts, provided with electric lamps and hoods, were erected on the outer margins of the 50-foot roadway around the ellipse in this park and connected with an electric cable laid underground in terra-cotta conduits. These lamps have been in successful operation since October last and are found to be a satisfactory addition to the improvement of the grounds.

WASHINGTON MONUMENT.

The monument has been opened to visitors daily, Sundays and holidays excepted, and the elevator has been run every day that the monument was open, with the exception of seven days in November when it became necessary to stop it to permit of repairs being made to the boilers and machinery, and four days at the end of June, when the supply of fuel and the appropriation were exhausted. There were 175,174 to the top of the shaft during the year, of which number 109,653 made the ascent in the elevator and 65,521 by the stairway, making a total of 297,145 persons who have visited the top since the monument was opened to the public on October 8, 1888. A number of arrests were made for defacing the walls of the monument, and similar acts of vandalism were committed by visitors, the perpetrators of which were not discovered. The iron and wood work on lower floor of shaft, to the height of 30 feet, was given two coats of white lead and oil, and the wood and iron work on upper floor was also painted. A wooden partition was erected across the west alcove on lower floor, converting it into a store-room for such articles as are in daily use about the monument. The memorial stones and the walls at the entrance to shaft have been frequently cleaned with pumice-stone and water, and the windows at top have been reglazed as required.

The heating-pipes on lower floor were extended by adding 95 linear feet of new pipe, and a steam-regulator was put in place by which the pressure upon them from the boilers could be controlled. An oil-stove was purchased for heating the upper floor. The granolithic pavement around the base of the monument having shrunk away from the walls from one-fourth to three-fourths of an inch, the space was grouted with cement and sand afterwards painted.

In the engine-house the wood-work and iron ceiling were repainted, and a space directly over the engines was sheathed with wood to lessen the condensation of steam, which drops upon the machinery. In the boiler-house the wood-work was given two coats of paint, the walls whitewashed, a work-bench for use of engineers constructed, a new iron cover furnished for man-hole of coal-vault, and the drain-pipes cleaned out. In the lodge-house a new hopper was placed in the gentlemen's toilet-room, and some necessary pointing up of the walls to stop leaks was done. This work upon the lodge-house was executed by the contractors who erected the building under a clause in their contract providing that all defects occurring during a period of one year from date of completion and acceptance should be made good by them.

The steam and electric plants were maintained in good order during the year. A new lower front section for boiler No. 1 was put in place, a new center column purchased to replace one that was badly cracked, and the furnaces of both boilers relined with fire-brick. A number of new joints were made in the main steam-pipe in the tunnel between boiler and engine houses, and a new automatic trap put in place to drain the expansion joints on this pipe. Two additional man-holes were constructed on top of the pipe-tunnel to afford necessary ventilation when repairs to the steam-pipes are in progress. The man-hole in the tunnel, which by the improvements in the grounds now finds itself in the roadway near the shaft, was provided with a tight cover to prevent the escape of steam which would be likely to frighten horses, and a 10-inch iron and terra-cotta pipe was run from the man-hole a distance of 104 feet into the lawn surface as a vent for the man-hole and tunnel. New friction-blocks were put on elevator-engine and the belt of latter repaired. The commutator-strip on armature of electric dynamo was repaired and a new head put in piston. The shaft was rewired from the 250-foot landing down to the 100-foot landing, and new electric lamps and receptacles put in to replace the old ones. The electric plant was increased by the addition of four lights in elevator-car, one in plummet-house, and one in store-room, and a search-light was placed upon the top of car. The expenditure of fuel required to operate the elevator and electric-light machinery is about 1 ton of coal per day and 3 cords of wood per month.

The elevator and its machinery have been inspected once each month by an expert agent of the manufacturers and daily by the employés at the Monument before carrying any passengers. The car was given two coats of paint inside and out, and the old cane seats on the settees replaced with perforated wooden ones. A new set of gibs for side guides, a set of rubber gaskets for throat gibs, and a spiral spring for safety dogs have been furnished. At the 490-foot landing a pair of guide-rollers were put up to prevent the cables from chafing against the diagonal rods, an electric annunciator was put in the car by which signals may be received from the engine-room and the lower and upper floors, and an idler pulley was put in place at the top of elevator-shaft in connection with the hand rope of elevator-car, so that in case of the

breaking of the hand-rope the conductor will have full control of the engine. A large drip-pan was purchased and suspended under the main pulleys to prevent the grease and oil from dropping on the top of the car, and the wire cables were given a coat of lamp-black and boiled oil.

WASHINGTON MONUMENT GROUNDS.

The work of grading and laying out the grounds around the Monument has been continued. An area of about 20 acres has been graded, covered with a heavy coating of compost followed by a covering of soil 4 inches deep, and the larger part of this area has been sown down in grass seed. Four thousand one hundred cubic yards of soil was purchased under contract and used in completing this surface grading. Gravel roadways, containing an area of 8,952 square yards, have been constructed on the east side of the grounds in accordance with the plan prepared for their improvement. The material used in constructing the foundation of these roadways consisted of about 1,630 cubic yards of broken stone and concrete, which was hauled and deposited on the grounds without expense to the United States by contractors who were engaged in making street improvements under the District government. The first coating of gravel used on the new roadways was taken from a condemned roadway in the grounds, which is to be filled up and turned into lawn surface, and 1,506 cubic yards of unscreened gravel were purchased and used as a finishing coat. The stone curbing at entrance to the old roadway from Fourteenth street, which has been abandoned, was reset and the sidewalk pavement relaid. Two thousand four hundred and sixteen linear feet of cobblestone gutters, 2½ feet wide, and 490 feet, 3 feet wide, have been laid along margins of the new roadways, and 15 new brick drain-traps constructed. To connect these traps with the main sewer there has been laid 397 feet of 12 inch terra-cotta pipe, 90 feet of 10-inch, 633 feet of 8-inch, and 862 feet of 6-inch, making 1,982 feet in all. A double line of sods has been laid on the ground along the margins of the new-made gutters, and a triangular piece of lawn surface east of the Monument and another near the lodge-house have also been sodded and top-dressed with fine soil.

The grade of that portion of the roadway running in front of the lodge has been raised about 3 feet to relieve an abrupt incline. A large quantity of earth and clay, about 23,550 cubic yards, has been deposited upon the monument grounds without cost to the United States by contractors and others, who find this a convenient dumping ground, and has been used in grading the low grounds north of the Monument; about 2,567 cubic yards of gravel and other road-making material have been received from the same sources, and this has been piled for future use in laying out additional roadways. The main roadway from B street northwest to the nurseries has been resurfaced with 2,860 cartloads of unscreened gravel, hauled from the gravel bank on reservation 17; the lawns have been frequently mown; the gutters and drain-traps cleaned as often as required, and a quantity of sand suitable for use in paving gutters has been collected from washes after heavy rains and piled for future use.

GREENHOUSES AND NURSERY.

One new greenhouse was constructed during the year; it is 120 feet long, 12 feet wide, and 9 feet high; the brick walls are 4 feet high and

9 inches thick, with a 14-inch footing; the house is heated by two small brick furnaces with 24 feet of iron and 96 feet of terra-cotta flues; a stoke-hole 8 feet by 6½ feet by 6 feet, lined with a 14-inch brick wall, was constructed at the south end of the house.

There are now fifteen greenhouses in all in the nursery grounds, covering an area of 23,347 square feet. These houses were overhauled during the year and all repairs needed to put them in good condition were made; the entire wooden and glass superstructure of house No. 3 (100 feet by 12 feet) was rebuilt and painted; in house No. 9, 24 feet of new wall-plate was put in and twenty-seven of the ventilating sash were repaired; in house No. 12 four rafters were spliced and fourteen ventilating sash were repaired: in house No. 14 four new posts for supporting roof were put in; the roofs of ten houses were reputtied, 160 feet of new staging, 3 feet wide, constructed, and 868 feet of old staging repaired; the facia boards and legs of staging in houses Nos. 1 and 2 were repainted. A brick walk, 96 feet long and 2½ feet wide, was laid in house No. 10, and one 96 feet long by 2 feet wide was constructed in house No. 13. Leaking joints in the hot-water pipes of all the houses were recalked, the flues of seven boilers were opened and cleaned, and five brick chimneys were repaired. A frame building 35 feet by 20 feet, by 20 feet for use as a work-shop, was constructed in the nursery grounds from old material on hand, received when the shops and sheds attached to the State, War, and Navy Departments building were demolished. The roof of a store-room 16 feet by 20 feet was covered with tarred felt, 41 new sash 6 feet by 3 feet for cold frames were made and 41 old ones were repaired, 36 repainted, and 34 reglazed. Fifty-four straw mats 7 feet by 5 feet were made for protecting the plants in the cold frames and a large number of plant-boxes 3 feet by 1 foot by 3 inches were made and 30 repaired. The coal-bins were repaired, a new platform and steps put up at door of the office, and 4,500 wooden marking pegs made. Two thousand four hundred feet of additional shelving was put up in the greenhouse for holding young plants, a new tin gutter 120 feet long by 4 inches wide was placed on house No. 15, and a cold frame 120 feet long and 6 feet wide was built on the west side of the house.

During the late summer and fall of 1889, 5,126 summer bedding plants and 8,000 chrysanthemums were sent out for planting in the parks. There were planted in the greenhouse for winter bloom 2,163 carnations, 1,439 roses, 1,480 smilax, 424 begonias, 348 alyssum, 134 abutilons, 149 bouvardia, 350 pansies, 32 rose geraniums, and 215 heliotropes, a total of 6,734 plants. For early spring bloom there were planted, in the cold frames, 847 pansies and 250 violets, and there were potted and boxed for winter forcing 1,200 freesia, 2,400 tulips, 1,968 Dutch hyacinths, 2,000 narcissus, 4,000 Roman hyacinths, 500 lilium Harrisii, 500 lilium auratum, and 5,000 convallaria majalis, in all 17,568. There were purchased during the year 53,000 bulbs for setting out in the parks and as stock for the nursery. During the winter and early spring months about 385,000 ornamental foliage and flowering plants, consisting of 47 species divided into 184 varieties, were propagated, nearly all of which were set out in the parks during May and June. Four hundred and sixty shrubs and 26 ornamental trees were lifted from the nursery and planted in various parks during the year. A lath-house 35 feet square and 12 feet high was constructed for use in hardening off subtropical plants, and in the spring the flower-beds in the nursery were stocked with ornamental plants and 7,961 plants and 8,460 bulbs were planted for stock.

The area of the nursery was increased by clearing a piece of ground

at the southwest corner, containing an area of about one-half an acre, covering it with good soil and inclosing it with 304 feet of wooden paling and 144 feet of iron fence and an arbor vitæ hedge. One hundred and twenty feet of 1¼-inch water-pipe were laid and two stand-pipes with hose-valves erected for irrigating purposes. The lawn surfaces in the nursery were regularly mown during the growing season, washouts in the gravel roads and walks repaired, the flower-beds, young trees, and shrubs were worked and watered, the evergreens freed from caterpillars, and tender shrubs mulched to protect them from frost during the winter months. A roadway 210 feet long and 12 feet wide, composed of 4 inches of broken stone and 6 inches of ashes, was constructed through the west side of the nursery to permit carts to reach the new compost grounds on the river flats.

SMITHSONIAN GROUNDS.

The watchman's lodge on the Seventh street side of the park was raised, the space under it filled in with gravel, and the building repainted. One thousand seven hundred and fifty-nine square yards of new asphalt pavement were laid on the roadways east and west of the National Museum and an asphalt walk, covering an area of 445 square yards, was laid on the path leading from the road entrance near the lodge on Seventh street to the Museum Building; in doing this work about 500 cubic yards of gravel were excavated and used in repairing the main drives in this park and in Henry and Seaton parks. A small gravel walk, covering an area of 114 square yards, was constructed in the southern part of the park and extensive repairs were made to the other gravel roadways and walks, worn-down places in them being covered with fresh gravel and thoroughly compacted by rolling with a heavy roller. The lawn surfaces were mown and raked regularly during the growing season, the roadways and walks scuffled and their margins edged to preserve outlines, dead wood cut from the trees and shrubs, and the gutters and drain-traps maintained in a cleanly condition. The gravel roads were sprinkled daily during the dry season of the summer and the asphalt roads and walks were swept daily. Forty-three new park settees were placed in position in this park and in Seaton and Henry parks, and broken settees were hauled to the nursery shops and repaired. The large flower-bed in front of the National Museum was planted with decorative plants during the summer and in the autumn these were removed and replaced with 4,363 spring flowering bulbs in four varieties, viz: crocus, tulips, hyacinths, and scilla siberica. Three tons of hay were cut in these grounds in July, 1889, and stacked in the nursery for forage for the public animals. Worn-out places in the lawns and along the margins of roads and walks were resodded.

ARMY MEDICAL MUSEUM.

In the area between the center building and wings of the Army Medical Museum and Library, an asphalt pavement was laid covering an area of 690 square yards, and 44 square yards of the same pavement was laid along the west end of the building. A blind drain 225 feet in length was constructed along the base of the west and north walls of the west wing for the purpose of preventing dampness in the cellar. In constructing this drain a trench 7 feet deep and 2 feet wide was excavated, filled to a depth of 4 feet with broken rock and leveled up with a finer broken stone; upon this was laid a 6-inch terra-cotta pipe-

drain running the entire length of the trench, which was then filled to within 2 feet of its surface with a mixture of broken stone and gravel. This was covered with soil and resodded to conform to the surrounding surfaces. The work was completed by connecting the drain-pipe with the main drain and constructing two new brick drain-traps to receive surface water.

HENRY AND SEATON PARKS.

The lawns in these parks were mown and their margins edged, the gutters and drain traps cleaned, and the roads and walks scuffled and raked. The plank walks in Henry Park, which had floated from their position during heavy rains in July were relaid. Extensive repairs were made to the roadways and walks, an area of 63,000 square feet having been resurfaced with about 1,000 cubic yards of gravel procured from the gravel bank on Reservation No. 17 and from excavations made for new asphalt roadway and walks in the Smithsonian Grounds. The roadway around the building in Henry Park occupied by the Fish Commission, was widened, 93 cubic yards of rough earth excavated and removed, and 32 loads of broken stone and 14 loads of coarse gravel used in bottoming the new portion, which was then graded and surfaced with 115 cubic yards of unscreened gravel, covering an area of 9,825 square feet. The margins of the new roadway, covering an area of 564 feet, were resodded.

RESERVATION NO. 101.

This reservation, situated at the intersection of Maryland and Virginia avenues, between Seventh and Ninth streets, southwest, is partially occupied by the tracks of the Baltimore and Potomac Railroad. In order to meet the wishes of residents in its vicinity, that something be done to improve the appearance of the reservation, that portion of it lying north of the railroad tracks has been graded and inclosed with 148 iron park-posts and 1,293 feet of iron chain. It is not considered practicable to improve the southern portion of this open space so long as it is occupied by the railway tracks.

RESERVATIONS NUMBERED 108 AND 109.

These two reservations, situated on Delaware avenue and First street, between Virginia avenue and G street, southwest, contain an area of 10,815 and 2,580 square feet, respectively; they are unimproved and have been used by persons unknown to this office as a dumping-ground for miscellaneous rubbish. During the spring of 1890 all of this refuse, amounting to about 200 cart-loads, was gathered up and removed and the reservations left in a cleanly condition.

RESERVATIONS NORTH OF PENNSYLVANIA AVENUE AND WEST OF THE CAPITOL.

In all of the improved reservations in this section of the city the lawn surfaces were frequently mown during the growing season and their margins edged to preserve the outlines of roads and walks; the gutters were maintained in a cleanly condition and deposits of sand were removed from the drain-traps after rain-storms to prevent obstructions in drainage pipes leading therefrom. Worn down places in

the gravel walks were resurfaced with fresh gravel, and they were frequently rolled to render them smooth and compact; the lawn surfaces, young trees and shrubbery, flower beds and borders were frequently watered during the dry summer weather; all necessary pruning of flowering shrubs received attention, dead wood was cut out from trees of large growth, and cocoons and web-nests, etc., of caterpillars removed. The asphalt walks through various parks and the brick pavements around them were maintained in a cleanly condition, and needful care was exercised to have these prominent places of public resort present an attractive appearance. In the autumn of 1889 the flower-beds and borders in the parks and park places of this section were planted with chrysanthemums and early spring flowering bulbs, 4,000 of the former and 27,000 of the latter being used for the purpose. The lawn surfaces of various parks were top-dressed with compost, 86 new park-settees were placed in position, 72 old settees were removed and taken to the work-shop in the nursery for repairs, and all loose settees were restaked and refastened.

In Reservation No. 31, situated at Pennsylvania avenue, Thirteenth and E streets, northwest, an excavation was made for a fountain basin, a concrete bottom laid therein and inclosed with a brick wall 18 inches thick, capped with an ornamental coping of Euclid, Ohio, dressed stone. The necessary water-supply and drain-pipes were laid for the service of the fountain, and in the spring of 1890 the basin was planted with water lilies, the ground bordering it resodded and protected with a light stake-and-wire fence.

In Du Pont circle the trees, shrubs, gas-pipe and lamps, and drain-pipe on the line of New Hampshire avenue were removed for a sufficient width to permit of the laying of the new 48-inch water-main through the circle. They were replaced and the grounds restored to proper condition after the laying of the main was completed, the expense being defrayed by the officer in charge of the Washington Aqueduct.

In Iowa Circle the asphalt walks were repaired by filling the breaks in them with coarse gravel and cement-mortar and paving their entrances with brick; and in Reservation No. 34, at Pennsylvania avenue and Seventh street, northwest, the large shade trees therein were headed in to permit a more open view through the reservation.

Reservation No. 158, at the intersection of New York avenue, First and M streets, northwest, was, prior to the autumn of 1889, totally unimproved and consisted of a mound, irregular in shape, averaging about 7 feet above the sidewalk and covering an area of 13,000 square feet and containing 3,355 cubic yards of earth and clay. In October this mound was cut down, the material carted away, and the ground graded to a level with the adjacent sidewalks, the work being done by contract.

LAFAYETTE AND FRANKLIN SQUARES.

Two new short gravel walks were constructed at the centers of the east and west fronts of each of these parks leading from the street sidewalks to intersecting walks in the grounds; they were required for public convenience, the removal of the high iron fences formerly inclosing the parks rendering these midway entrances practicable. The area of the new walks is 126 square yards. Repairs were made to the other gravel walks, 38 cubic yards of unscreened gravel and 240 cubic yards of screened gravel being used for the purpose. The brick gutters, where out of repair, were taken up and relaid, and 478 linear feet of new gutters

were constructed on margins of walks not heretofore provided with them.

The brick pavement at the Sixteenth and H street entrance to Lafayette Square was taken up and relaid and new brick aprons constructed on each side of the asphalt walk at this entrance. Part of the large drain pipe on the south side of this square having become choked with tree roots and rendered unserviceable, it was taken up and replaced with 337 feet of new 10-inch, 210 feet of 8-inch, and 136 feet of 6-inch terra-cotta pipe. Portions of the drain from the watchman's lodge were also taken up and relaid, and 3 new brick drain-traps constructed and 5 old ones repaired.

In Franklin Square the hemlock spruce hedge screening the entrance to the retiring rooms in the lodge having died out in part, it was removed and replaced with an arbor vitæ hedge, 90 trees being lifted from the nursery for the purpose. Sections of the drain that were choked with roots were taken up, cleaned out, and relaid where in good condition, and those parts broken in removal were replaced with new terra-cotta pipe. In the spring the fountain basin was planted with water lilies.

In addition to the foregoing, the lawns were frequently mown, bare places in them resodded, and in the winter they were covered with good compost which was raked in the spring. The flower-beds were planted in the autumn with chrysanthemums and early spring flowering bulbs, which were replaced in the spring with summer decorative plants. Beds and vases were also planted with subtropical plants removed from the greenhouses for the summer.

STATUE TO MEMORY OF GENERAL LAFAYETTE.

The work of constructing the foundation for and superintending the erection of the pedestal and statue to the memory of General Lafayette and his compatriots having been assigned to me by the honorable the Secretary of War in March, 1890, the trees, shrubs, and lamp posts were removed from the site selected at the south central entrance to Lafayette Square, the asphalt and gravel walks cut out and an excavation of suitable dimensions made to receive the foundation; all drain, water, and gas pipes thereby exposed being cut out and re-connected outside. In this excavation there has been constructed a foundation consisting of a solid mass of Portland cement concrete 25 feet 9 inches square and 5 feet and 6 inches thick, extending 4 feet 9 inches below, and 9 inches above the ground line. Around the foundation a mound of earth and soil of suitable thickness has been constructed, extending outward a distance of 10 feet to meet the gravel walks on the north, east, and west sides, and the brick side-walks on the south side. The mound has been sodded and the necessary changes in the gravel walks around the site have been made. The first three courses of the granite sub-base and platform have been set in position by the contractor for that part of the work and they have been backed with cement concrete, leaving the foundation in readiness to receive the pedestal and statue.

JUDICIARY SQUARE.

The work of improving the grounds around the Pension Building was continued during the year. The ground east of the building was graded to conform to adjoining park surfaces, and 1,407 loads of earth removed during the progress of the work was hauled to the mound in

process of construction in Seaton Park, west of the Pennsylvania Railroad depot. The planting of flowering shrubs, trees, and evergreens was completed, a gravel roadway 30 feet in width constructed from Fourth street to the eastern entrance of the building, and 38 linear feet of 6-inch circular granite curbing was set in position to round the corners of the roadway at the street intersection; gravel walks were also made leading mainly to this entrance and connecting with intersecting walks through the grounds. The brick pavement at the entrance of the new road from Fourth street was removed and a granite block pavement, covering an area of 37 square yards, laid in its place; cobble-stone gutters 2 feet wide were constructed on each side of this road, and 228 square yards of cobble-stone approaches with aprons were laid at the entrances to the coal vaults of the building. Five brick drain-traps were constructed and 269 feet of 6-inch and 48 feet of 8-inch terra cotta pipe laid therefrom and connected with main drains to carry off the surface water from the grounds south of the building. The aggregate area of the new roads and walks is 1,114 square yards, and the materials used in making the foregoing improvements were 108 cart-loads of soil, used in top-grading lawn surfaces, in addition to that saved in plowing up the ungraded portions of the grounds; 84 cart-loads of sod used in sodding margins, 185 cart-loads of broken stone, 440 cart-loads of unscreened gravel, and 103 cubic yards of screened gravel used in constructing roads and walks, and 28 cart-loads of cobble-stone and 22 cart-loads of granite blocks used in paving. An asphalt path 6 feet wide and covering an area of 426 square yards was laid on the center of the walk from Fourth to Fifth street through the park on the line of F street, and an asphalt roadway pavement covering an area of 318 square yards was laid between the south entrance to the Pension Building and the fountain at that front for use as a carriage stand. An asphalt walk 5 feet wide and containing an area of 54 square yards was also laid on the center of the walk from Louisiana avenue to the west basement entrance of the City Hall Building. In addition to the foregoing, the main roadways and walks in the parks were resurfaced with fresh gravel, 600 cubic yards of material having been used in making repairs; the lawns were mown as often as required, bare places in them and on their margins resodded, the borders of walks edged, and gutters and drain-traps maintained in a cleanly condition.

RESERVATIONS EAST OF THE CAPITOL.

In Lincoln Square about 1,360 square yards of walk surface were resurfaced, 100 cubic yards of gravel being used for the purpose. The watchman's lodge was repainted and new plumbing fixtures placed therein. In the autumn the flower beds were planted with chrysanthemums and early spring flowering bulbs, which were removed in the spring and the beds replanted with summer decorative plants. The lawn surfaces were mown as required, and in the winter were top-dressed with compost. The drain from the fountains and from the watchman's lodge having become choked and unserviceable, it was taken up and 280 feet of 10-inch, 47 feet of 6-inch, and 26 feet of 4-inch new terra-cotta pipe were laid and connected with the public sewer. The iron post-and chain fence and lamp-posts on the south and west sides of the square were taken down, moved out, and re-erected at the inner edge of the brick sidewalks recently laid by the District government, slightly increasing the park area.

In Stanton Square all of the foot-walks were repaired, about 452 cubic yards of gravel having been used in resurfacing an area of 3,400 square yards. The lawns were mown, and three of the flower-beds were planted in the autumn with chrysanthemums and five with hyacinth, tulip, crocus, and scilla siberica bulbs, which were replaced in the spring with decorative plants.

In Folger Park about 930 square yards of walk surface were repaired with 37 cubic yards of fresh gravel, lawns were mown, shrubbery and young trees pruned, and the flower-bed around the fountain properly planted.

In Marion Park the center road was repaired, 47 cubic yards of gravel being used in resurfacing an area of 816 square yards. Lawns were frequently mown and small wire-fences erected to prevent trespasses over them.

In reservation at Maryland avenue, First and A streets, northeast, 37 cubic yards of fresh gravel was used in repairing 306 square yards of walk surface.

Reservation No. 207, at the intersection of North Carolina avenue, Ninth and A streets, southeast, was inclosed with an iron post-and-chain fence.

In all of the smaller reservations at the intersections of streets with avenues in this section of the city the lawns were frequently mown, shrubbery pruned, flower-beds planted, and these small public spaces maintained in a neat condition; and in the reservation at Pennsylvania avenue, Eighth and E streets, southeast, sixteen shrubs were planted to replace dead ones.

RESERVATION NO. 17, GARFIELD PARK.

In the eastern section of the park about 2,000 square yards of walk and 1,850 square yards of roadway surface were repaired, 465 cubic yards of gravel being used for the purpose; a trench 339 feet in length was opened and 1,017 feet of tile pipe, 2 inches in diameter, laid therein and covered with about 8 inches of broken stone for draining wet places in the grounds; 705 linear feet of cobble-stone gutters, 18 to 30 inches wide and 612 feet 24 inches wide, were constructed on margins of gravel roads to carry off surface water. The curbing on the north side of the line of E street was reset and the sidewalk and gutters repaired. The lawns were frequently mown and during the winter were dressed with compost; trees and shrubs were pruned, 28 ornamental trees and 85 shrubs were planted to replace dead ones, and flower-beds were prepared and stocked with suitable plants.

In the western section the roads were dressed with fresh gravel, an area of about 1,900 square yards being resurfaced with 166 cubic yards of gravel; 200 cubic yards of broken stone and 275 cubic yards of coarse gravel were used in repairing the roadway on the line of Virginia avenue; 450 feet of 10-inch and 264 feet of 8-inch terra-cotta drain-pipe were laid on the north side of this road and 5 brick drain-traps, covered with iron gratings, were built and connected therewith; 1,064 linear feet of cobble-stone gutters, from 2 to 3 feet wide, were constructed on the margins of the roadway, and about $1\frac{1}{4}$ acres of the ground adjoining it on the north, hitherto only rough graded, were ploughed and harrowed, a portion of it surfaced with good soil and sown with grass seed. In the northeast part of this section 12 trees and 143 flowering shrubs were planted, and 6 trees and 72 shrubs were planted in other portions of the ground to replace dead ones. The lawns were mown and top-

dressed with compost, and trees and shrubs were pruned and refastened.

SETTEES, MANURE, AND REMOVING SNOW AND ICE.

One hundred new settees were purchased during the year and placed in various parks, 158 old settees were repaired, 200 repainted, and 667 irons made and used in refastening loose settees; 27 boxes were made and placed under settees in several of the parks as receptacles for waste paper and other litter removed from the lawns and paths, and 72 park signs were painted and lettered and placed in position.

Additional ground for mixing and storing compost was prepared on the Potomac flats east of the nursery and a roadway constructed to it from the latter; 1,025 cubic yards of stable manure and 1,050 cubic yards of soil were purchased, thoroughly mixed and spread upon the lawns of various parks during the winter, and 1,500 bushels of oyster-shell lime were purchased and used in making leaf-mold in connection with dead leaves hauled from the parks.

Owing to the unusually mild winter of 1889–'90 it was not found necessary to expend any of the appropriation for removing snow and ice, and the entire amount, $1,200, will revert to the Treasury.

CONSTRUCTING, REPAIRING, AND PAINTING IRON FENCES, PAINTING WATCHMEN'S LODGES, ETC.

New iron post-and-chain fences were erected around reservation No. 101, at the intersection of Virginia and Maryland avenues, between Seventh and Ninth streets southwest, and reservation No. 207, at the intersection of North Carolina avenue, Ninth, and A streets, southeast, and 350 iron tops were purchased and placed on the iron posts around various parks to replace those that were broken or missing, and all other necessary repairs were made to the iron fences as required.

The high iron fence inclosing the Executive Mansion Grounds, consisting of 544 panels, 3 large iron vases within the grounds, the post-and-chain fences inclosing the reservations on Pennsylvania avenue between Eighteenth and Twenty-sixth streets northwest, and 1 drinking fountain, 4 lamp-posts, and 3 flower vases therein were painted, and the post-and chain fences inclosing the following reservations were also painted: McPherson Square, Du Pont Circle, Reservation No. 101, at Maryland and Virginia avenues between Seventh and Ninth streets, reservations at Connecticut avenue and M street northwest, Connecticut avenue and Twentieth street northwest, Massachusetts avenue and Twentieth street northwest, Massachusetts avenue and P street northwest, and Massachusetts avenue and Sixteenth street northwest. The watchmen's lodges in the following parks were repainted: Executive Mansion Grounds, Lafayette Square, Franklin Square, Washington Circle, Lincoln Square, and Smithsonian Grounds.

STATUES, FOUNTAINS, WATER-PIPES, AND GAS LAMPS.

The pedestals of the statues in Washington Circle, Farragut, McPherson, Lafayette, Lincoln, and Stanton Parks, Du Pont, Thomas, and Scott Circles, and in triangle at Pennsylvania avenue and Ninth street, were carefully cleaned.

The large fountains with basins in various parks were repaired and cleaned, jets put on, and new overflow pipes put in several of them; a

new iron drain-pipe was put in place for the service of the large iron fountain in the reservation at Twenty-eighth and M streets and repairs were made to the drinking fountains and new dippers put on as required.

Attention was paid to the water-pipes during the year, all leaks in them or in the shut-off valves being promptly repaired. In the autumn the hose valves were removed from the pipes and stored in the nursery shops for safe-keeping; during the winter months the valves were examined and all requiring it were reground, repaired, and put in perfect order. In the spring the valves were replaced upon the pipes; 313 feet of new water-pipe were laid in the nursery grounds and two stand-pipes with hose valves placed thereon. New 2-inch shut-off valves were placed in several of the parks to replace those that had become broken or otherwise unserviceable. A portion of the old pipe line supplying the Executive Mansion with water from the spring in Franklin Square was taken up and replaced with 402 feet of new 4-inch iron pipe and all necessary reconnections made. Where the pipe terminates in the Executive Mansion Grounds it was lowered about 10 inches to increase the flow. The water in the cistern in these grounds was pumped out and the vault thoroughly cleaned; the storage reservoir in Franklin Square was also cleaned and repaired. One thousand seven hundred feet of new rubber hose were purchased to replace old hose no longer serviceable.

The gas lamps in the public grounds were maintained in good order during the year, all broken glass in the lanterns being replaced with new; new tops were placed on some of the lamp-posts, and two new posts were erected in the Smithsonian Grounds to replace broken ones. The average number of burners lighted nightly during the year was 318.

EXECUTIVE MANSION, GREENHOUSES, AND GROUNDS.

In the mansion the boilers in kitchen and laundry were taken down, cleaned, repaired, and reset, and new galvanized-iron pipes put in to replace lead ones; the furnaces and stoves were repaired; the machinery of elevator carefully examined, put in good order, and the car revarnished; a large linen closet was constructed on the floor of half-story between first and second floors; one of the bath-rooms was reconstructed and a new tub placed in position, and the plumbing in another bath-room was altered and a doorway cut through into same; the plumbing arrangements in one of the toilet-rooms were changed and improved, and another supplied with a ventilating shaft; a vestibule was constructed at west end of lower corridor, over the doorway leading into conservatory; a new girder put in place under the floor of Red Parlor, and new cloth-covered swing-doors were hung between the private dining-room and butler's pantry; a new mantel and fire-place, with tiled hearth, were put in place in southeast room on second floor; repairs were made to the tin roof, and the copper leaders therefrom and the galvanized-iron caps on six chimneys were repaired and reset; a new sink was put in the butler's pantry, and the walls and woodwork of the room repainted and the ceiling recalcimined; the woodwork in bath-rooms was revarnised, the wash-boards in basement cleaned and repainted, and in one servant's room the walls were calcimined and the wood-work painted; the wood-work and walls of lower main corridor were repainted, the ceiling and cornice cleaned, and the center of ceiling of main vestibule refrescoed; the library was repapered and repainted, and the cabinet room and room adjoining were repainted and

the ceilings frescoed; the walls of East Room and Blue Parlor were cleaned and the lower portions repainted; the paint in the Red and Green Parlors, the main vestibule, the private dining-room, and one bed-chamber was touched up, the side walls of another chamber repapered, and all window-sills on second floor repainted; the hat and cloak boxes used at receptions were restained, oiled, and renumbered, and on the outside of the mansion the bases of north portico columns, the base under iron fence, and the pillars at front entrance gates were repainted. Some of the old-style call-bells were replaced with electric bells, the large water-filter and one of the pumping engines were repaired, stand-pipes for use in case of fire were erected in the basement corridor, one at east and the other at west end, and each provided with 100 feet of $1\frac{1}{4}$-inch hose, and two new fire extinguishers were purchased. An electric fire-alarm system was placed in the mansion, without expense to the United States, by the company operating it; this system consists of a large fire-alarm box placed in the main vestibule and connected with the fire-alarm telegraph of the District, and six small auxiliary fire-alarm boxes placed at convenient points through the house and connected with the large one. The entire lighting system of the mansion was overhauled and put in complete order, and repairs were made to the plumbing arrangements as required; the portrait of one of the ex-Presidents was relined, cleaned, and varnished, and three other portraits were also cleaned and revarnished; new carpets were purchased for the public hall adjoining main vestibule, for the Red Parlor, and the lower main corridor, and purchases were made of new floor linen and matting for the East Room and matting for the private dining-room, such of the old matting from the East Room as was fit for the purpose being cut up and relaid in some of the smaller rooms on second floor. Some new articles of furniture were purchased, and five large new awnings were purchased and placed in position on the south portico.

In the stable of the Mansion repairs were made to the floors, stalls, and windows, some necessary whitewashing was done, and the old asphalt pavement between the carriage-houses was removed down to the base and a new asphalt surface laid, covering an area of 201 square yards.

Necessary repairs were made to the greenhouses; new slate and wood benches were placed in the rose-house, and old rafters in that house and in the conservatory and camelia-house were replaced with new; in the grapery all the old glass was removed and the house reglazed; all new woodwork in the houses and the sashes of cold frames received two coats of paint, and the exterior of three houses and the roof of another were repainted; the boilers were cleaned and repaired where required, all broken glass was replaced with new, a new brick cold frame was constructed east of orchid-house, and new brick walks laid between some of the houses. Necessary care was extended to the large collection of plants, and desirable varieties for decorating the grounds were propagated.

In the grounds the stone gutters at the foot of embankment on west side having settled unequally they were taken up, the foundation repaired where required, and the gutter-stones reset; the gravel walks south of the Mansion were recoated with good binding gravel, thoroughly rolled; the lawns were mown about once every ten days during the growing season, and those at the north front were top dressed during the winter with good compost. All the ailanthus trees in the south grounds were taken up and some of the other trees were thinned out. One thousand one hundred square yards of brick gutters were repaired

and 75 yards of new gutter was laid. In the autumn the flower-beds were planted with about 23,000 hyacinth, tulip, and crocus bulbs, and in the spring these were removed and replaced with summer decorative plants and subtropical plants removed from the green-houses.

TELEGRAPH TO CONNECT THE CAPITOL WITH THE DEPARTMENTS AND GOVERNMENT PRINTING OFFICE.

The main and local batteries were maintained in good working condition, and all crosses and obstructions were removed from the wires as soon as possible; all old and decayed fixtures on the roofs of the Treasury and Interior Departments, the Department of Justice, the Second Auditor's Office, and the Bureau of Statistics were removed and replaced with new fixtures, well braced and re-insulated; the entire line of poles was carefully gone over, all old and decayed cross-arms and unserviceable wire removed were replaced with new, and re-insulated where necessary. New guy-wires were placed on the poles where needed, and wherever permitted by the District authorities the branches of trees growing up into the line-wires were trimmed. All guys and wires of every description attached to the poles without permission from this office were removed. All the old Department wires in the Government Printing Office were removed and replaced with new; all dead wires were removed from the cable pole at Seventeenth and G streets northwest, and the old wires on the cable pole on the north side of the Capitol grounds were replaced with new. All the cables in the basement of the Capitol were overhauled, tested, and put in good working order, and the instruments which were removed from the operators' tables in the Senate and House of Representatives and stored during the recess were replaced and reconnected prior to the re-assembling of Congress. One pole on H street, near North Capitol street, that was broken off during a storm, was reset. Four extra wires were run into the office in the Executive Mansion, and an additional set of instruments placed in position and connected therewith. The Department of Agriculture, the new building of the Signal Office, and the United States navy pay office were connected with the line during the year. All instruments, switch-boards, etc., found out of order were promptly repaired. The under-ground telegraph cable crossing Seventh and B streets northwest was lowered $3\frac{1}{2}$ feet at that point to accommodate the new cable railway, the cost of the work being defrayed by the Washington and Georgetown Railroad Company. A new ground wire was run into the War Department building, and the telegraph office in that building was moved into another room, and the necessary changes made in the wires. Part of the under-ground cable at B street and New Jersey avenue northwest that was found to be in the way of certain connections to be made with the new water-main was taken up and relaid, 96 feet of new cable being used in making the reconnection. The cost of this work was paid by the officer in charge of the Washington Aqueduct.

Attention is again respectfully invited to the fact that it is becoming more and more difficult to operate the overhead telegraph system, owing to the fact that the trees along the line are gradually growing up into the wires and interrupting the continuity of the electrical currents, particularly during wet and windy weather. Not only have the present poles become too short, but many of them are rotting at the butts and are in constant danger of breaking from their own weight or of being blown down during storms. The necessity for either replacing the overhead wires with underground cables, or of replacing the present poles with taller ones, is obvious. An estimate for placing them under-

ground is herewith submitted. An alternative estimate for placing them overhead is also submitted.

SURVEYING AND DRAUGHTING.

The draughtsman of public buildings and grounds is also custodian of the old records of the city of Washington in charge of this office, and his time is mainly taken up with their care. He is required to exhibit them to owners of city property, to lawyers and real-estate agents, and to produce them frequently in court. For about three-quarters of the past fiscal year he has been engaged in searching these old records with the assistant district attorney, and by request of the latter, for evidence relating to the case of The United States *vs.* Morrison *et al.*, known as "the Potomac Flats case," and appearing as a witness in that case. He has also partially prepared plats showing reservations numbered 30, 37, 38, 39, 40, 41, 42, 43, 72, 73, 151, 152, 153, 157, 158, 205, 206, and 209, and the additional improvements to date at Judiciary Square and the Monument grounds.

In order that the draughtsman may devote his whole time to surveying the public grounds and making the plans of them that are required by law to be kept in this office, a clerk should be provided to take charge of the old records, and the estimate submitted last year for that purpose is again presented and recommended.

Estimates for the fiscal year ending June 30, 1892.

Salaries of employés, public buildings and grounds, etc:	
One office clerk	$1,600.00
One messenger	840.00
One public gardener	2,000.00
One clerk in charge of old public records of Washington City	1,500.00
One electrician and telegraph lineman	1,000.00
Overseers, foremen, draughtsmen, gardeners, mechanics, and laborers	30,000.00
One captain of the watch	1,200.00
One day watchman at Lafayette Square	660.00
One day watchman at Franklin Square	660.00
Two day watchmen in Smithsonian Grounds, at $660 each	1,320.00
Two night watchmen in Smithsonian Grounds, at $720 each	1,440.00
One day watchman at Judiciary Square	660.00
One night watchman in Judiciary Square	720.00
One day watchman at Lincoln Square and adjacent reservations	660.00
One day watchman at Iowa Circle	660.00
One day watchman at Thomas Circle and neighboring reservations	660.00
One day watchman at Washington Circle and Rawlins Square	660.00
One day watchman at Dupont Circle and neighboring reservations	660.00
One day watchman at McPherson and Farragut squares.	660.00
One watchman at Stanton Square and neighboring reservations	660.00
Two day watchmen at Henry (Armory) and Seaton squares, at $660 each	1,320.00
One night watchman at Henry (Armory) and Seaton squares	720.00
One day watchman at Mount Vernon Square and adjacent reservations	660.00
One day watchman at grounds south of the Executive Mansion	660.00
One watchman for greenhouses and nursery	660.00
One day watchman for Marion Square, Folger Square, and adjacent reservations	660.00

One day watchman at Garfield Park	$660.00	
One night watchman at Garfield Park	720.00	
Contingent and incidental expenses	500.00	
		$54,780.00
Improvement and care of public grounds:		
Improvement and maintenance of grounds attached to the Executive Mansion; ordinary care of greenhouses and nursery; ordinary care of Lafayette and Franklin squares; construction and repair of post-and-chain fences, repair of high iron fences, and constructing stone coping about reservations; manure and hauling same; painting watchmen's lodges, iron fences, vases, lamps, and lamp-posts; purchase and repair of seats; purchase and repair of tools; trees, tree and plant stakes, labels, lime, whitewash, stock for nurseries; removing snow and ice; flower-pots, twine, baskets, wire, splints, moss, and lycopodium; care, construction, and repair of fountains; abating nuisances; improvement, care, and maintenance of various reservations; improvement, care, and maintenance of Smithsonian Grounds and Judiciary Square	61,700.00	
Granite curbing about Lafayette and Franklin squares.	10,000.00	
Care and improvement of Monument grounds	10,000.00	
Continuing improvement of reservation No. 17, and site of old canal northwest of same	10,000.00	
Laying asphalt walks in various reservations	5,000.00	
Improvement and care of Henry and Seaton parks	5,000.00	
Lodges for park watchmen in Stanton, Mount Vernon, Iowa, Dupont, Thomas, McPherson, and Folger reservations, at $500 each	3,500.00	
Supplying and keeping supplied the 76 vases in the new Pension Building with suitable plants and shrubs, and caring for the same, in accordance with the joint resolution of Congress approved March 29, 1886	1,000.00	
Replacing the old flagging pavement of the sidewalk on Pennsylvania avenue in front of the Executive Mansion by a granolithic pavement	7,800.00	
The construction of a large greenhouse at the propagating gardens for palm and tropical plants of large growth, needed for tropical bedding, etc., in the public parks during the summer months	6,000.00	
The improvement of Howard University Park (reservation No. 246)	5,000.00	
		125,000.00
Care of, repairs, fuel, etc., Executive Mansion:		
Care, repair, and refurnishing the Executive Mansion, to be expended by contract or otherwise, as the President may determine	35,000.00	
Fuel for Executive Mansion, greenhouses, and stables	3,000.00	
Care and necessary repair of greenhouses	5,000.00	
		43,000.00
Lighting the Executive Mansion and the public grounds:		
Electric lights for 366 nights, from 7 posts, at 60 cents per light per night, $420 per night	1,537.20	
Gas, pay of lamp-lighters, gas-fitters, and laborers, purchase, erection, and repair of lamps and lamp-posts, purchase of matches, and repairs of all kinds; fuel and lights for office and office stable, for watchmen's lodges, and for greenhouses at the nursery: *Provided*, That for each 6-foot burner not connected with a meter in lamps on the public grounds no more than $20 shall be paid per lamp for gas, including lighting, cleaning, and keeping in repair the lamps, under any expenditure provided for in this act; and said lamps shall burn not less than 2,600 hours per annum; and authority is hereby given to substitute other illuminating material for the same or less price, and to use so much of the sum hereby appropriated as may be necessary for that purpose	14,000.00	
		15,537.20

Repairs to water-pipes and fire-plugs:		
Repairing and extending water-pipes, purchase of apparatus for cleaning them, purchase of hose, and for cleaning the spr ngs and repairing and renewing pipes of same that supply the Capitol, the Executive Mansion, and the building for the State, War, and Navy Departments		$2,500.00
Telegraph to connect the Capitol with the Departments and Government Printing Office:		
Replacing the entire everhead system of wires with duplicate 6-conductor underground cable, being a total distance of about 10,500 linear feet	$18,465.00	
(An alternative estimate amounting to $1,600 is also submitted for replacing the present poles with new and taller poles, and if an appropriation for that purpose be made it should be accompanied by authority to erect the poles.)		
Care and repair of existing lines	1,500.00	
		19,965.00
Total		260,782.20

Washington Monument, elevator, electric lights, and machinery connected therewith: The following estimate for operating the elevator, the electric lights and machinery connected therewith for the fiscal year ending June 30, 1892, is submitted:		
One custodian, at $100 per month	1,200.00	
One steam engineer, at $90 per month	1,080.00	
One assistant steam engineer, at $70 per month	840.00	
One fireman, at $60 per month	720.00	
One assistant fireman, at $60 per month	720.00	
One conductor of elevator car, at $75 per month	900.00	
One attendant on floor, at $60 per month	720.00	
One attendant on top floor, at $60 per month	720.00	
Three night and day watchmen, at $60 per month each	2,160.00	
Fuel, lights, oil, waste, packing, tools, matches, paints, brushes, brooms, lanterns, rope, nails, screws, lead, electric lights, heating apparatus, oil-stoves for elevator car and upper and lower floors, repairs to engines, boilers, dynamo, elevator, and repairs of all kinds connected with the Monument and machinery, and purchase of all necessary articles for keeping the Monument, machinery, elevator, and electric-light plant in good order	3,600.00	
		12,660.00

As some of the foregoing estimates are larger than the amounts heretofore appropriated, and as others are for new work, it is deemed advisable to submit the following brief explanation in reference thereto:

First.—One public gardener, $2,000. I have asked for an increase in the salary of the public gardener, a position now so satisfactorily filled by Mr. George H. Brown. The duties of the office require that the gentleman who fills it shall be thoroughly skilled in the culture of trees, shrubs, and plants, and shall have a practical knowledge of civil engineering as applied to landscape gardening. Mr. Brown combines these attributes, to which he adds taste, industry, and integrity. His duties take him from one end of the city to the other. He is directly responsible for the care of the valuable collection of plants in the propagating garden, and superintends the propagation of plants that are annually raised for the public grounds, which this year numbered about 385,000.

Second.—One clerk in charge of old public records of Washington City, $1,500. These records include maps, deeds, record books, letters, etc., from the organization of the original board of commissioners, near the close of the last century, up to 1867, when the duties were turned over to the Chief of Engineers; they are constantly examined by attor-

neys and others interested in lands in Washington, and the person in charge of them is frequently required to produce them in courts; to index them properly, to be able to turn at once to the details of any question raised, requires familiarity with every paper. This work has for the last few years been intrusted to the only draughtsman allowed this office, and during the past year three-quarters of his time has been actually employed on this duty. It is desirable that this appropriation be made in order that the draughtsman may be permitted to attend to the necessary and legitimate duties of his office.

Third.—For one telegraph lineman, $1,000. The telegraph system under charge of this office includes about 8 miles of overhead wire and 2.6 miles of underground cable. The are twenty offices connected with these lines, the main battery being at this office; the lineman is constantly engaged in the care of the main and local batteries and such necessary repairs and extensions as a system of wires of this kind requires; he is industrious, efficient, and capable, and has won the confidence of all with whom he has come in contact by faithful attention to his duties.

Fourth.—An estimate for a captain of the watch is submitted and recommended. Such an officer is much needed in order that the park watchmen may be under proper supervision.

Fifth.—Judiciary Park contains an area of 19 acres, and should have a special watchman at night. An attempt at highway robbery was recently made there.

Sixth.—Estimates for a day watchman for Marion and Folger Squares and adjacent reservations, and for a day watchman and a night watchman for Garfield Park, are submitted and recommended. Marion and Folger Squares contain an aggregate area of about 3 acres, and Garfield Park contains an area of about 24 acres. They are highly improved and the necessity for providing watchmen for their care is apparent.

Seventh.—It will be observed that the estimates for "improvement and care of public grounds" is submitted in a smaller number of separate items than heretofore. A large number of items, being for such purposes as are required regularly every year, are lumped together in a single item; the several items, however, being enumerated, and it is recommended that the appropriation be made in that way instead of designating a specific sum for each of these small objects. Great labor in keeping the accounts would be saved, and the full amount of the appropriation be made available if a lump sum could be appropriated. It is not always practicable to spend an exactly even number of dollars for a particular purpose. When a specific amount is stated for each object it must not be exceeded, and the result is that some remnants of those small items can not be used at all. The method of appropriating a lump sum, as here suggested, seems to be in accordance with the practice of Congress in other cases, as, for example, for the regular supplies and incidental expenses of the Quartermaster's Department, pages 92 and 93, Book of Estimates, 1890–'91.

The aggregate amount requested for the consolidated items exceeds, in the sum of $10,250, the appropriation made for similar purposes for the fiscal year 1890–'91. The excess arises as follows, viz, $1,000 is asked for painting watchmen's lodges, iron fences, etc., instead of $750 last appropriated; $20,000 is asked for improvement, care, and maintenance of various reservations, in place of the $12,000 granted this year; and $7,000 is asked for improvement, care, and maintenance of Judiciary Square, in place of $5,000 last granted. It is proposed to improve as many as possible of the two hundred unimproved reservations; each

year from three to five are added to the list of improved reservations, and if the funds now requested become available eight or ten can be added during the fiscal year ending June 30, 1892; as reservations are thus improved the expense of the care of the whole is slightly increased, for the improvements must be maintained.

Eighth.—For placing granite curbing about Lafayette and Franklin Squares, $10,000 is asked. The beauty of these handsome parks will be greatly enhanced by placing around them granite curbings similar to those used around parks of the same style in the larger cities elsewhere.

Ninth.—For the care and improvement of the Monument Grounds, $10,000. The estimated total cost of completing the improvement of these grounds in accordance with the approved plan is $40,000, of which amount $10,000 can be profitably expended during the fiscal year ending June 30, 1892.

Tenth.—For laying asphalt walks in various reservations, $5,000. It is proposed to replace with first-class asphalt walks the gravel paths in Washington Circle, Mount Vernon Square, Executive Mansion Grounds (south side), Lincoln Square, Stanton Square, Folger Square, Marion Square, Henry and Seaton Parks, and to renew those in Farragut Square and Iowa Circle. In the late fall, winter, and early spring these walks are muddy and pedestrians seek the lawns, which are thus destroyed by trespassers. The amount of these paths which it is proposed to lay this year is about 3,500 square yards. Each autumn it becomes necessary to put down plank walks which must again be removed in the spring. If asphalt walks are laid the annual expense incident to plank walks will be avoided.

Eleventh.—For improvement, care, and maintenance of Henry (Armory) and Seaton Parks, $5,000. These reservations, extending from Seventh street to the Botanical Gardens, cover an area of 34 acres, with road and walk surfaces of over 10,000 square yards. They are in an advanced state of improvement. Their beauty has been marred by the depot and tracks of the Baltimore and Potomac Railroad. A mound has been constructed around the depot, upon which it is intended to plant trees and shrubs, so that in time the depot will be hidden partially from view. The materials for this mound have thus far been obtained free of expense to the United States, and it is now proposed to grade the mound and to seed and plant it. The funds requested are needed for this purpose, and for the care of roads, lawns, gutters, etc., and laying out additional paths.

Twelfth.—For lodges for park watchmen in Stanton, Mount Vernon, Iowa, Dupont, Thomas, McPherson, and Folger reservations, at $500 each, $3,500. The watchmen in these reservations are exposed to the inclemency of the weather at all seasons of the year. Ordinary humanity seems to call for this appropriation.

Thirteenth.—For supplying and keeping supplied the vases in the new Pension building with suitable plants and shrubs, $1,000. The joint resolution of Congress, approved March 29, 1886, requires that the seventy-six large vases on the upper corridor of the new Pension building shall be filled and kept filled with suitable plants and shrubs. This estimate is submitted in order that the terms of the law may be complied with.

Fourteenth.—An estimate of $7,800 is submitted for constructing a granolithic pavement on the sidewalk on Pennsylvania avenue in front of the Executive Mansion. The old flagging pavement at present composing this sidewalk is in very bad condition and should be replaced by one that will compare more favorably with the pavement on the east,

in front of the Treasury Department, and that on the west in front of the War Department.

Fifteenth.—An estimate amounting to $6,000 is also submitted for constructing a large greenhouse at the propagating gardens for palms and subtropical plants. The greenhouse structures now existing at the gardens are of small size and not of sufficient capacity to accommodate that class of plants.

Sixteenth.—An estimate amounting to $5,000 is submitted for improving reservation No. 246, known as Howard University Park. This park contains an area of about 11⅓ acres and is unimproved.

Seventeenth.—It is recommended that an addition of $10,000 be made to the appropriation for "care, repair, and refurnishing the Executive Mansion." This old building needs continual repairs and repainting to make it and maintain it in a neat and habitable condition. Much of the furniture is old and needs renewing, while new carpets and curtains are required in many of the rooms.

During the past fourteen years the appropriations for the Mansion have been as follows:

1878	$20,000	1885	$22,000
1879	25,000	1886	*16,000
1880	25,000	1887	16,000
1881	20,000	1888	16,000
1882	50,000	1889	16,000
1883	40,000	1890	16,000
1884	28,000	1891	25,000

It will be observed that between July 1, 1885, and June 30, 1890, the appropriations have been much less than prior to the first-mentioned date. The result has been a deterioration which now renders it necessary to make expenditures larger than the average.

Eighteenth.—The amount allowed for the past and present fiscal years for electric lights is 40 cents per night. The price paid by the Commissioners of the District of Columbia for similar lights on the streets and avenues of this city is 60 cents per light per night, and my estimate for the fiscal year 1892 is based upon the latter figure.

Nineteenth.—An estimate is again submitted for replacing the overhead wires between the Capitol and the Departments with a duplicate underground six-wire cable. The growth of the trees on the sidewalks renders it absolutely necessary, in order to maintain telegraphic communication over these wires, either to erect at once taller poles, at a cost of about $1,600, or to lay an underground cable, at a cost of $18,465. It appears to be the will of Congress that no more overhead wires shall be placed in this city (see District of Columbia appropriation act of July 18, 1888). Otherwise I should recommend the appropriation of the smaller amount.

Twentieth.—I recommend that the salaries of the two steam engineers at the Washington Monument be increased from $80 and $60 to $90 and $70 per month, respectively. The duties of these two men are of great importance; upon their efficiency and intelligence depend, to a great extent, the lives of those who use the elevator; the increase asked is small and the men deserve it. I also recommend that the pay of the two firemen be placed at $60 per month each. That is the rate allowed firemen in the Executive Departments, and there appears to be no reason why the firemen at the Monument should receive less.

The item for fuel, lights, oil, waste, repairs, etc., should be increased from $2,600 to $3,600 for the purpose of painting the iron-work in the interior of the Monument at a cost of $800, for renewing the tubes in

* Including $4,000 for new roof.

No. 1 boiler at a cost of $120, and repairing the steam-pipe tunnel at a cost of $80.

Financial statement for fiscal year ending June 30, 1890.

Title of appropriation.	Available at beginning of fiscal year.	Expended during fiscal year.	Unexpended balance to be covered into the Treasury.
Improvement and care of public grounds, 1890	$67,950.00	$66,442.70	$1,507.30
Repairs, fuel, etc., Executive Mansion, 1890	24,000.00	23,951.47	48.53
Lighting, etc., Executive Mansion, etc., 1890	16,022.00	14,966.62	1,055.38
Repairs to water-pipes and fire-plugs, 1890	2,500.00	2,454.07	45.93
Telegraph to connect the Capitol with the Departments and Government Printing Office	1,250.00	1,250.00	.....
Contingent expenses public buildings and grounds under Chief of Engineers, 1890	500.00	499.54	.46
Salaries of employés public buildings and grounds under Chief of Engineers, 1890	47,620.00	47,620,00	.....
Care and maintenance of the Washington Monument, 1890	10,500.00	10,495.94	4.06
Completion of the Washington Monument*	4,428,52	4,199.74	.....
Building for Army Medical Museum and Library (sundry civil act, March 2, 1889)	1,550.00	1,498.75	51.25
Water supply, Executive Mansion (act October 2, 1888)*	5,300.00	.....	.....

* Not a fiscal year appropriation.

A catalogue of the principal trees and shrubs growing in the parks, compiled by Mr. Geo. H. Brown, public gardener, is here appended.

I am, General, very respectfully, your obedient servant,

O. H. ERNST,
Col., U. S. A., Major Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

APPENDIX A, TO ANNUAL REPORT OF OFFICER IN CHARGE OF PUBLIC BUILDINGS AND GROUNDS FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

Catalogue of native and foreign deciduous and evergreen trees and shrubs forming the ornamental plantings in the parks and park places of the public grounds of Washington, D. C., compiled by Mr. George H. Brown, public gardener.

DECIDUOUS TREES.

Botanical name.	Common name.	No. of trees in parks.	No. of varieties.
Acer dasycarpum	Silver-leaved maple		
saccharinum	Sugar maple		
platanoides	Norway maple		
laetum	Colchican maple		
dasycarpum Weirii	Wier's cut-leaved maple		
macrophyllum	Large-leaved maple		
pseudo platanus	Sycamore maple		
platanoides Schwedlerii	Schwedler's purple maple		
pseudo platanus purpurea	Common purple maple		
striatum	Striped-bark maple		
rubrum	Scarlet or swamp maple		
tartaricum	Tartarian maple	3,500	24
negundo	Ash-leaved maple		
platanoides laciniatum	Eagle's claw maple		
campestra	European cork-bark maple		
polymorphum	Common Japan maple		
polymorphum atropurpureum	Purple-leaved Japan maple		
polymorphum sanguineum	Blood-red-leaved Japan maple		
Japonicum aconitifolium	Aconite-leaved Japan maple		
Japonicum aureum	Golden-leaved Japan maple		
Japonicum macranthum	Large leaved Japan maple		
Japonicum pendulum	Weeping Japan maple		
Japonicum palmatum	Palmate-leaved Japan maple		
Japonicum microphyllum	Small-leaved Japan maple		

Catalogue of native and foreign deciduous and evergreen trees and shrubs, etc.—Continued.

DECIDUOUS TREES—Continued.

Botanical name.	Common name.	No. of trees in parks.	No. of varieties.
Aesculus hippocastanum	European horse chestnut	500	3
rubicunda	Red flowering horse chestnut		
Lyonii	Yellow flowering horse chestnut		
Alnus glutinosa laciniata	Cut leaved European alder	10	2
firma	Japan alder		
Aralia Spinosa	Hercules club or Angelica tree	50	3
Japonica	Japan Aralia		
Mandschurica	Mandschurian Aralia		
Acacia Nemu	Japan Acacia	30	1
Asimina triloba	Papaw tree	10	1
Betula alba	European white birch	80	5
purpurea	Purple-leaved birch		
laciniata	Cut-leaved weeping birch		
papyracea	Paper or canoe birch		
lenta	Sweet or cherry birch		
Broussonetia papyrifera	Paper mulberry	10	1
Cerasus padus	European bird cherry	120	4
avium alba plena	Double white flowering cherry		
pumila pendula	Dwarf weeping cherry		
Japonica rosea pendula	Japan weeping cherry		
Castanea Vesca	European chestnut	30	3
Americana	American chestnut		
Japonica	Japan chetnut		
Cornus florida	White flowering dogwood	100	3
flora rubra	Red flowering dogwood		
pendula	Weeping dogwood		
Chionanthus Virginica	Virginia fringe tree	150	2
maritima	Large-leaved white fringe tree		
Carya Amara	Bitter-nut hickory	6	2
alba	Shell-bark hickory		
Carpinus betulus	European hornbeam	36	3
Americana	American hornbeam		
Virginica	Hop hornbeam, or ironwood		
Crataegus coccinea	Scarlet fruited thorn	24	2
oxycantha flora plena Paulii	Paul's double flowering thorn		
Catalpa bignonioides	Common Indian bean	300	5
bignonioides aurea	Golden-leaved Indian bean		
Bungeii	Bunge's Indian bean		
Kempferii	Japan Indian bean		
nana	Dwarf Indian bean		
Cercis Canadensis	American Judas tree	200	2
Japonica	Japan Judas tree		
Celtis occidentalis	American nettle tree	200	2
orientalis	Oriental (Asiatic) nettle tree		
Cladastris Tinctoria	Yellow wood	20	1
Cytisus laburnum	Golden chain tree	20	1
Caragana arborescens	Siberian pea tree	12	1
Cercidiphyllum Japonicum	Japan cercidiphyllum	10	1
Diospyros Virginica	American persimmon	30	2
Kaki	Japan persimmon		
Euonymus Americana	American spindle tree	200	3
Europea	European spindle tree		
alatus	Winged spindle tree		
Fraxinus Americana	American white ash	300	8
aucubaefolia	Aucuba-leaved ash		
Juglandifolia	Walnut-leaved ash		
excelsior	European ash		
aurea	Gold-barked ash		
concavaefolia variegata	Variegated-leaved ash		
excelsior pendula	European weeping ash		
ornus	Manna or flowering ash		
Fagus ferruginea	American beech	200	7
sylvatica	European beech		
atropurpurea	River's purple beech (European)		
pendula	European weeping beech		
cuprea	Copper-leaved beech		
heterophylla	Cut-leaved beech		
asplenifolia	Fern-leaved beech		
Gleditschia triacanthos	Three-thorned honey locust	30	3
sinensis	Chinese honey locust		
bujotii pendula	Weeping honey locust		
Gymnocladus Canadensis	Kentucky coffee tree	50	1
Gordonia pubescens	Downy Gordonia	10	1
lasianthus	Hairy Gordonia		
Halesia diptera	Two-winged snow drop or silver bell	60	2
tetraptera	Four-winged snow drop or silver bell		1
Hammamelis Virginica	American witch hazel	20	1
Hovenia dulcis	Sweet Hovenia	6	1
Hippophea ramnoides	Sea buckthorn	5	

Catalogue of native and foreign deciduous and evergreen trees and shrubs, etc.—Continued.

DECIDUOUS TREES—Continued.

Botanical name.	Common name.	No. of trees in parks.	No. of varieties.
Idesia polycarpa	Many-fruited idesia	40	
Juglans cineria	Butternut walnut	36	3
nigra	Black walnut		
regia	Madeira nut		
Kolreuteria paniculata	Chinese Kolreuteria	200	1
Liquidamber stryaciflua	Sweet-gum tree	100	1
Liriodendron tulipifera	Tulip poplar	60	1
Lindera benzoica	Benzoin or Benjamin tree	3	1
Laurus sassafras	Sassafras tree	20	1
Larix Americana	Hackmatac, or American larch	6	2
Europea	European larch		
Magnolia acuminata	Cucumber tree	250	11
conspicua	Yulan magnolia		
purpuera	Purple-flowered magnolia		
sonlangeana	Hybrid Chinese magnolia		
Lenneii	Lenne's hybrid magnolia		
glauca	Glaucous-leaved magnolia		
Macrophylla	Largest-leaved magnolia		
stellata	Star-flowered magnolia		
tripetala	Three-petaled magnolia		
gracilis	Slender-stemmed magnolia		
grandiflora	Large-flowered evergreen magnolia		
Melia azederach	Bead tree or Bride of India	6	1
Morus Downingii	Downing's mulberry	6	1
Maclura Aurantiaca	Osage orange tree	10	1
Nyssa maltiflora	Sour-gum tree	10	1
Pyrus malus floribunda	Common flowering apple	100	4
spectabilis	Chinese double flowering apple		
toringo	Toringo crab apple		
coronaria	Sweet-scented crab apple		
Persica vulgaris flora plena alba	Double white flowering peach	80	5
camellaflora plena	Double camellia flowered peach		
versicolor plena	Double variegated flowered peach		
foliis purpurea	Blood leaved flowering peach		
pendula	Weeping peach		
Prunus pissardii	Purple-leaved plum	100	1
Pavia flava	Sweet buckeye	80	2
Pavia macrostachya	Dwarf buckeye		
Paulownia imperialis	Empress tree of Japan	30	1
Platanus occidentalis	American plane tree	40	2
orientalis	Oriental plane tree		
Planera acuminata	Kiaki elm	10	1
Populus balsamifera	Balsam poplar	200	6
alba	Silver poplar		
fastigiata	Lombardy poplar		
grandidentata	Aspen poplar		
monilifera	Carolina poplar		
Van Geertii	Golden-leaved poplar		
Paliuria acculeatus	Christ's thorn	8	1
Ptelea trifoliata	Hop tree	25	1
Phellodendron amurense	Chinese cork tree	6	1
Quercus alba	American white oak	2,000	20
aquatica	Water oak		
cerris	Turkey oak		
coccinea	Scarlet oak		
daimio	Japan oak		
imbricaria	Shingle oak		
macrocarpa	Overcup oak		
palustris	Pin oak		
pannonica	Hungarian oak		
phellos	Willow oak		
nigra	Black oak, or black jack oak		
lyrata	Lyre-leaved oak		
prinos	Chestnut oak		
robur	English oak		
robur concordia	Golden-leaved oak		
robur lonettii	Lonette's oak, or long-leaved oak		
robur pendunculata	British oak		
obtusiloba	Post oak		
rubra	Red oak		
robur fastigiata	Pyramidal oak		
Rhus cotinus	Purple fringe tree, or smoke tree	300	5
osbeckii	Osbeck's Chinese sumach tree		
copallina	Copal sumach tree		
glabra laciniata	Cut-leaved sumach		
typhina	Stag's horn sumach		
Robinia pseudo acacia	Yellow locust tree	6	1
Salisburia adiantifolia	Japan ginkgo tree	40	1

Catalogue of native and foreign deciduous and evergreen trees and shrubs, etc.—Continued.

DECIDUOUS TREES—Continued.

Botanical name.	Common name.	No. of trees in parks.	No. of varieties.
Salix babylonica	Babylonian weeping willow	100	6
caprea	Goat willow		
caprea pendula	Kilmarnock weeping willow		
annularis	Curled-leaved willow		
vitellina	Golden willow		
rosemarinifolius	Rosemary leaved willow		
Sophora Japonica	Japan sophora	100	2
Japonica pendula	Weeping Japan sophora		
Sorbus Americana	American mountain ash	100	4
aucuparia	European mountain ash		
aucuparia pendula	Weeping mountain ash		
quercifolia	Oak-leaved mountain ash		
Taxodium distichum	Bald cypress	60	2
Sinensis pendula	Chinese cypress		
Tilia americana	American linden	600	6
macrophylla	Large-leaved linden		
Europea	European linden		
argentea	Silver-leaved linden		
aurea	Gold-barked linden		
pyramidalis	Pyramidal linden		
Ulmus americana	American elm	1,200	5
campestris	European elm		
campestris montana	Scotch elm		
campestris purpurea	Purple-leaved elm		
campestris camperdownii	Camperdown elm		
Total number of deciduous trees in the park plantings of the public grounds, and in the nursery grounds at the propagating gardens		12,261	.....

DECIDUOUS SHRUBS.

Azalea pontica	Asiatic wood honeysuckle	300	30
nudiflora	Naked flowered wood honeysuckle		
viscosa	American wood honeysuckle		
(Ghent azaleas) varieties not named.			
Amorpha glabra	Glabrous leaved amorpha. (False indigo shrub.)	200	3
fruticosa	Shrubby, pendulous, amorpha. (False indigo shrub.)		
fragrans	Fragrant amorpha. (False indigo shrub)		
Andromeda racemosa	Spike flowered andromeda	25	2
mariana	Stagger bush		
Abelia rupestris	Abelia (rock growing)	12	1
Barberis vulgaris	Common European barberry	500	4
atropurpurea	Purple-leaved barberry		
thunbergii	Thunbergs Japan barberry		
hakodate	Japan, barberry		
Baccharis halmifolia	Groundsel shrub	12	1
Buddlea lindleyana	Chinese buddlea	10	1
Colutea arborescens	Tree colutea (bladder senna)	300	2
cruenta	Oriental colutea (bladder senna)		
Clethra alnifolia	Alder leaved pepper bush	200	2
acuminata	Acuminate leaved pepper bush		
Callicarpa purpurea	French mulberry	300	2
americana	American callicarpa		
Calycanthus floridus	Sweet-scented shrub	25	1
Ceanothus americana	New Jersey tea	10	1
Cephalanthus occidentalis	Button bush	25	1
Cotoneaster frigida	Frigid cotoneaster	40	3
simondsii	Simond's cotoneaster		
rotundifolia	Round-leaved cotoneaster		
Corylus purpurea	Purple-leaved hazel	200	1
Cydonia japonica, tri-color	Variegated leaved Japan quince	800	6
grandiflora	Large-flowered Japan quince		
carnea plena	Flesh-colored flowering Japan quince		
princeps	Scarlet-flowered Japan quince		
rosa plena	Rose-colored double-flowered Japan quince		
mallardii	Mallard's Japan quince		
Coronilla emerus	Scorpion senna	50	1
Cornus alba sanguinea	Red-twigged dogwood	400	6
alternifolia	Alternate-leaved dogwood		
mascula	Cornelian cherry		
mascula variegata	Variegated-leaved dogwood		
paniculata	Panicled dogwood		
stolonifera	Wild red osier dogwood		

Catalogue of native and foreign deciduous and evergreen trees and shrubs, etc.—Continued.

DECIDUOUS SHRUBS—Continued.

Botanical name.	Common name.	No. of trees in park.	No. of varieties.
Deutzia fortunii	Fortune's deutzia	1,200	6
candidissima flora plena	Double white-flowering deutzia		
crenata flora plena	Double pink-and-white-flowering deutzia		
scabra	Rough-leaved deutzia		
gracilis	Slender-stemmed deutzia		
parviflora	Small-flowering deutzia		
Desmodium penduliflorum	Pendulus flowered desmodium	300	2
canadensis	Canadian desmodium		
Daphne genkwa	Japan daphne	25	2
mezereum	Mezereon daphne		
Eleagnus argentea	Silver-leaved oleaster	200	1
Exochordia grandiflora	Large-flowered exochordia	100	1
Forsythia fortunii	Forunes forsythia golden bell	1,500	3
suspensa	Weeping forsythia golden bell		
virridissima	Japan forsythia golden bell		
Genista scoparius	Scotch broom	300	1
Hibiscus syriacus compacta	Compact althea	1,200	5
syriacus atro rubens	Dark purple-flowered althea		
syriacus Duc de Brabant	Lilac flowered althea		
totus albus	Large white-flowered althea		
flora plena Buistii	Buists variegated althea		
Hydrangea otaksa	Otaksan Japan hydrangea	1,500	7
paniculata grandifolia	Large panicle flowered hydrangea		
quercifolia	Oak-leaved hydrangea		
hortensis	Common hydrangea		
hortensis nivea	Silver-leaved hydrangea		
Thomas Hogg	White-flowered hydrangea		
stellata flora plena	Star-flowered hydrangea		
Hypericum patulum	Spreading St. John's wort	300	2
prolificum	Shrubby St. John's wort		
Itea virginica	Virginian itea	10	1
Jasminum nudiflorum	Naked flowered jasmine	1,500	1
Ligustrum vulgare	Common European privet	600	2
ovalifolium	Californian privet		
Lonicera fragrantissima	Fragrant upright, or bush honeysuckle	1,200	3
standishii	Standish's upright honeysuckle		
tartarica	Tartarian honeysuckle		
Lagerstrœmia indica rubra	Red-flowered lagerstrœmia (crape myrtle)	100	2
alba	White-flowered lagerstrœmia (crape myrtle).		
Lycium barbarum	Barbary box thorn	100	1
Myrica cerifera	Candle berry myrtle	10	1
Nandina domestica	Chinese nandina	6	1
Philadelphos coronarius	Mock orange	800	5
gordonianus	Gordon's mock orange		
grandiflorus	Large-flowered mock orange		
Keteelerii flora plena	Double-flowering mock orange		
zeyherii	Zepherii mock orange		
Ribes aureum	Missouri currant	20	1
Shepherdia argentea	Buffalo berry	300	1
Spirea Reevesii	Reeve's spirea, meadow sweet	2,000	14
Reevesii plor plena	Reeve's double flowering spirea, meadow sweet.		
prunifolia	Plum-leaved spirea, meadow sweet		
Billardii	Pink spirea billards, meadow sweet		
Sorbifolia	Elder-leaved spirea, meadow sweet		
opulifolia aurea	Golden guelder rose-leaved spirea, meadow sweet.		
opulifolia	Guelder rose-leaved spirea, meadow sweet.		
Thunbergii	Thunberg's spirea, meadow sweet		
Douglassii	Douglass,' spirea, meadow sweet		
callosa	Dwarf pink-flowering spirea, meadow sweet.		
callosa alba	Dwarf white-flowering spirea, meadow sweet.		
crispifolia	Curled-leaved spirea, meadow sweet		
tomentosa	Wooly-leaved spirea, meadow sweet		
Stuartia pentagynia	White-flowered stuartia	10	1
Symphoricarpus racemosus	Snow berry	600	2
purpureas	Purple-berried Indian currant		
Syringa josika	Josika's lilac	400	6
persica	Persian lilac		
Sinensis	Chinese lilac		
Chas. the 10th	Hybrid lilac		
vulgaris	Common lilac		
vulgaris grandiflora	Large flowered lilac		

Catalogue of native and foreign deciduous and evergreen trees and shrubs, etc.—Continued.

DECIDUOUS SHRUBS—Continued.

Botanical name.	Common name.	No. of trees in park.	No. of varieties.
Tamarix Africana	African tamarisk	800	2
Gallica	French tamarisk		
Viburnum lantana	Wayfaring tree	1,000	5
opules sterilis	Common snow ball		
plicatum	Japan snow ball		
oxycoccus	Cranberry tree		
rugosum	Rough-leaved viburnum		
Vitex agnus castus	Chaste tree	150	1
Weigela amabilis	Lovely weigela	1,200	6
rosea	Rose-colored flowered weigela		
hortensis nivea	White-flowered weigela		
Lavalee	Lavalee's weigela		
Des Boisii	Desbois's weigela		
Steltznerii	Steltzner's weigela		
Zizyphus jujuba	Jujube tree	20	1
Total number of ornamental flowering deciduous shrubs in the park plantings of the public grounds and in the nursery grounds at the propagating gardens		20,860	

EVERGREEN TREES.

Abies alba	White spruce fir	800	25
nigra	Black spruce fir		
canadensis	Hemlock spruce fir		
canadensis macrophylla	Broad leaved hemlock spruce fir		
Douglassii	Douglas's spruce fir		
pungens	Colorado blue spruce fir		
excelsa	Norway spruce fir		
excelsa conica	Dwarf pyramidal spruce fir		
Gregoriana	Gregory's dwarf spruce fir		
inverta	Inverted stemmed spruce fir		
morinda	Himalayan spruce fir		
orientalis	Oriental spruce fir		
Alcockianna	Alcock's spruce fir		
polita	Tiger's tail spruce fir		
amabilis	Lovely silver fir		
balsamea	Balsam silver fir		
Cephalonica	Cephalonian silver fir		
concolor	White silver fir		
Hudsonica	Hudson's Bay silver fir		
nobilis	Noble silver fir		
Nordmanniana	Nordmann's silver fir		
numidica	Algerian silver fir		
pichta	Siberian silver fir		
pinsapo	Pinsapo silver fir		
pectinata	Common silver fir		
Biota orientalis	Chinese arbor vitæ	4,000	4
aurea	Golden oriental arbor vitæ		
compacta	Compact arbor vitæ		
elegantissima	Pyramidal golden arbor vitæ		
Cedrus Atlantica	Mount Atlas, or African cedar	15	3
libana	Cedar of Lebanon		
deodara	Indian cedar		
Ilex aquifolium	European holly in variety	200	2
opaca	American holly		
Juniperus Chinensis	Chinese juniper	300	6
suecica	Swedish juniper		
hibernica	Irish juniper		
sabina	Savin juniper		
Virginiana	Red cedar		
pygmea	Very dwarf juniper		
Libocedrus decurrens	Californian libocedrus	12	1
Pinus Austriaca	Austrian pine	400	10
ayacahuite	Acayahuite pine		
cembra helvetica	Swiss stone pine		
cembra Mandschurica	Mandschurian pine		
excelsa	Bhotan pine		
mugho	Mugho pine		
strobus	White or Weymouth pine		
strobus pumila	Dwarf white pine		
Sylvestris	Scotch pine		
Laricio	Corsican pine		

Catalogue of native and foreign deciduous and evergreen trees and shrubs, etc.—Continued.

EVERGREEN TREES—Continued.

Botanical name.	Common name.	No. of trees in parks.	No. of varieties.
Retinospora obtusa	Obtuse-leaved Japan cypress	400	8
ericoides	Heath-like Japan cypress		
pisifera	Pea-fruited Japan cypress		
pisifera aurea	Golden-leaved Japan cypress		
plumosa	Plume-like Japan cypress		
plumosa aurea	Golden plume-like Japan cypress		
squarrosa	Rough-scaled Japan cypress		
plumosa argentea	Silver plume-like Japan cypress		
Taxus baccata	Common European yew	400	5
baccata aurea	Golden yew		
adpressa	Short-leaved yew		
elegantissima	Pyramidal yew		
fastigiata	Irish yew		
Total number of evergreen trees in the plantings of the parks of the public grounds and in the nursery at the propagating gardens		6,527	

EVERGREEN SHRUBS.

Aucuba Japonica	Japan aucuba	24	6
Japonica bicolor	Two-colored leaved aucuba		
alba variegata	White variegated aucuba		
aurea variegata	Gold-blotched aucuba		
macrophylla	Large-leaved aucuba		
marginata aurea	Gold-margined aucuba		
Buxus microphylla	Small-leaved box	300	4
sempervirens	Tree box		
balearica	Minorca box		
macrophylla	Broad-leaved box		
Euonymus Japonica	Japan euonymus (spindle tree)	500	4
Japonica argentea variegata	Silver-leaved euonymus (spindle tree		
Japonica aurea variegata	Gold-leaved euonymus (spindle tree)		
Japonica radicans variegata	Dwarf creeping variegated euonymus (spindle tree).		
Osmanthus illicifolius crispa	Crisp-leaved osmanthus	24	4
argentea variegata	Silver variegated-leaved osmanthus		
aurea variegata	Gold variegated-leaved osmanthus		
myrtifolus	Myrtle-leaved osmanthus		
Rhododendron maximum	American mountain laurel	200	12
ponticum, calawbiense	In unnamed varieties		
Total number of evergreen shrubs planted in various parks and in the nursery grounds at the propagating gardens		1,048	

RECAPITULATION.

Total number of deciduous trees	12,261	
Total number of deciduous shrubs	20,860	
		33,121
Total number of evergreen trees	6,527	
Total number of evergreen shrubs	1,048	
		7,575
Aggregate		40,696

APPENDIX C C C.

SURVEY OF ROAD FROM THE AQUEDUCT BRIDGE TO MOUNT VERNON, VIRGINIA.

REPORT OF LIEUTENANT-COLONEL PETER C. HAINS, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., July 1, 1890.

GENERAL: I have the honor to forward herewith my annual report for the year ending June 30, 1890, on the survey of a road from the Aqueduct Bridge to Mount Vernon.

Very respectfully, your obedient servant,

PETER C. HAINS,
Lieutenant-Colonel, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF ROAD FROM THE AQUEDUCT BRIDGE TO MOUNT VERNON, VIRGINIA.

The act of Congress approved February 23, 1889, provides for a survey of a national road from the Aqueduct Bridge to Mount Vernon, Va.

The work was assigned to my charge by letter of the Chief of Engineers, dated March 13, 1889.

The preliminary work was commenced in April, 1889, and the active field work about the middle of May. Three principal routes were surveyed and a number of points on each were connected with points on the adjacent ones. The profiles of the connecting lines were plotted, so that besides the three principal routes others can be made by combining parts of one with parts of another. The field work was completed about the middle of September, 1889, the field party brought in and disbanded, and the office work of plotting the data collected, preparing estimates, etc., commenced. The latter work was completed during January, 1890. I append a copy of my detailed report on the survey, made under date of January 4, 1890:

July 1, 1889, amount available	$7,473.46
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	5,360.75
July 1, 1890, balance	2,112.71
Total cost of survey	7,887.29

WAR DEPARTMENT,
Washington City, January 9, 1890.

The Secretary of War has the honor to transmit to Congress, in compliance with the act approved February 23, 1889, a letter from the Chief of Engineers, dated the 8th instant, together with a copy of the report, maps, and estimates submitted by Lieut. Col. Peter C. Hains, Corps of Engineers, the officer detailed to "make the necessary surveys for a national road from a point in Alexandria County, Virginia, at or near the Virginia end of the Aqueduct Bridge, and thence through the counties of Alexandria and Fairfax, in said State, to Mount Vernon."

REDFIELD PROCTOR,
Secretary of War.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., January 8, 1890.

SIR: The act of Congress approved February 23, 1889, provides as follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized and directed to detail one or more engineer officers of the Army to make the necessary surveys for a national road from a point in Alexandria County, Virginia, at or near the Virginia end of the Aqueduct Bridge, and thence through the counties of Alexandria and Fairfax, in said State, to Mount Vernon, who shall report the same, together with the estimated cost of building such road, to the Secretary of War, who shall transmit the same to Congress.

SEC. 2. That the sum of ten thousand dollars, or so much thereof as may be necessary, to be expended under the direction of the Secretary of War, be, and the same is hereby, appropriated, out of any money in the Treasury not otherwise appropriated, to defray the expenses of the United States in carrying out the provisions of this act: *Provided*, That nothing herein shall be construed to bind the Government of the United States to pay for any portion of the right of way for the avenue contemplated by this act.

Approved February 23, 1889.

In accordance with this act, and with your approval, the charge of this survey was assigned to Lieut. Col. P. C. Hains, Corps of Engineers, on the 13th of March, 1889. The field-work was begun May 10, 1889, and completed September 17, 1889. The final report, accompanied by drawings, sections, and estimates was finished January 4, 1890.

In accordance with the act, this report, with maps and estimates, is respectfully submitted.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., January 4, 1890.

GENERAL: The act of Congress approved February 23, 1889, is as follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized and directed to detail one or more engineer officers of the Army to make the necessary surveys for a national road from a point in Alexandria County, Virginia, at or near the Virginia end of the Aqueduct Bridge, and thence through the counties of Alexandria and Fairfax, in said State, to Mount Vernon, who shall report the same, together with the estimated cost of building such road, to the Secretary of War, who shall transmit the same to Congress.

SEC. 2. That the sum of $10,000, or so much thereof as may be necessary, to be expended under the direction of the Secretary of War, be, and the same is hereby, appropriated out of any money in the Treasury not otherwise appropriated, to defray the expenses of the United States in carrying out the provisions of this act. *Provided*, That nothing herein shall be construed to bind the Government of the United States to pay for any portion of the right of way for the avenue contemplated by this act.

Approved, February 23, 1889.

By order of the Chief of Engineers, United States Army, the work was assigned to my charge March 13, 1889.

The field work was begun May 10, 1889, and finished September 17, 1889, the party being under the immediate charge of Mr. B. F. Mackall, civil engineer, whose report is appended hereto.

The survey was started from the south end of the Aqueduct Bridge, and covers all that section of country between Mount Vernon and Washington and the Potomac River, and a line nearly parallel to and distant from it about 3 miles. In making the map of the region surveyed, advantage was taken of the work heretofore done by the Coast and Geodetic Survey, but the profiles were constructed from actual surveys and measurements on the ground.

The estimates are made from the profiles constructed on a horizontal scale of 1 inch to 200 feet and a vertical scale of 1 inch to 30 feet.

Three principal routes were surveyed, the first designated as the *eastern* or river route, the second the *middle*, and the third the *western*. A number of points on each route were connected with points on the

adjacent ones, and the profiles of the connecting lines plotted, so that, besides the three principal routes, others can be made by combining parts of one with parts of another. The survey of the three main routes, with their intermediate connections, furnishes, it is believed, all the information needed to base an estimate of the cost of constructing a "national road" to Mount Vernon. It is to be understood, however, that the several routes are laid down approximately. In many places the alignment could be somewhat changed to advantage, and the grades might in the same way be modified. Both can be done, within reasonable limits, without materially affecting the cost.

The country lying between the city of Washington and the Mount Vernon estate is generally of an undulating character. There are high points from which fine views are obtained, and, while they may not be termed grand, some of them are certainly beautiful. There are two valleys, the surfaces of which rise but little above tide-water. These are the valleys of Big Hunting Creek (sometimes called Cameron Run) and Four-Mile Run. The valley of Little Hunting Creek, a third depression, is not so low. The general course of these valleys is perpendicular to the general line of direction of a road to Mount Vernon, consequently they all have to be crossed, no matter what route be taken. The topography of the country admits of good grades, while it is sufficiently undulating to afford good drainage.

There are points of interest along all of the routes. Fort Myer and the National Cemetery at Arlington are near by. The old town of Alexandria, near which any route must pass, abounds in objects that were associated with the Father of his Country, while many of the hills are even yet occupied by the remains of old earthen forts built during the war for the Union.

In order to determine the kind of roadway that is called for in the act, the question occurs, What is its object? It is not for commerce. It has no military value. It does not partake of the nature of an ordinary work of internal improvement. It is true, it would be of great value to the section of country through which it would pass, but to the nation it has practically no pecuniary value. What, then, is the object? It is to commemorate the virtues of the grandest character in American history. It is to satisfy the cravings of a patriotic sentiment that fills the hearts of the American people to honor the name of Washington.

Whatever tends to keep alive the memory of his character and virtues will tend to make us all better citizens of the Republic. A road, therefore, built from the capital of the nation to the tomb of its founder, would not be such as is built for ordinary traffic. It should have the character of a monumental structure, such as would comport with the dignity of this great nation in such an undertaking, and the grandeur of character of the man to whom it is dedicated. The question of cost would be one of secondary consideration.

Such a national highway would be for all time. It would be always in a process of development. With the increase of population would come increased demands, for which provision must be made at the start, as far as human foresight can do so. A good road, 24 feet wide, would to-day meet the existing demands of travel, for there is not a fairly good road in existence between Mount Vernon and the capital, though the distance is only about 14 miles; but a great nation like ours would hardly undertake to construct a country road to Mount Vernon as a memorial to Washington. If undertaken at all, something far better is called for. It should be wide enough to give it character, and still have

room for future adornment and expansion. The grades should be light, the alignment in graceful curves, and it should pass over some of the high grounds from which the beautiful scenery along the route could be enjoyed, and possibly near the places that Washington himself frequented—places that now have a historical interest because associated with him. Parking, either on each side or in the center, or both, should form an essential feature. The roadway should be well paved and well kept. In fine, it should be such a work as no American need feel ashamed of. The crossings of all streams, as well as of the tracks of the several railroads that run into Alexandria and Washington, should be on permanent constructions of stone masonry, the designs of which should be in harmony with the monumental character of the work. Iron trussed bridges, while they might be used in the early stages, would be neither permanent nor in keeping with the general design of a work of this character. If used at all, they should be only as temporary expedients.

The act making the appropriation calls for "surveys of a national road from a point in Alexandria County, Virginia, at or near the Virginia end of the Aqueduct Bridge." As before stated, the survey was started from the south end of that bridge, but it would be far more in keeping with its character as a "national road" to have it start from some point on the Arlington estate, at the terminus of a handsome bridge spanning the Potomac. The question of constructing a memorial bridge across the Potomac at or near the foot of New York avenue, connecting Arlington Cemetery with the capital, has already been the subject of Congressional consideration, and doubtless a bridge of some kind will be constructed there at no distant day. The Virginia end of such a bridge would seem to be the most suitable point of starting for a "national road" to Mount Vernon. Not only is the point of starting more in keeping with the general design, but the distance from the capital to Mount Vernon would be materially shortened.

The initial steps in such a work need not be extravagantly costly. Much of it would at first be of a temporary character, to be replaced by more permanent structures later on. It is necessary, however, to provide ample width. A right of way 250 feet wide has been provided for in the estimates. Perhaps the greater part of it would be donated by people along the route; but $100 per acre has been assumed in the estimates as a safe valuation. Over this strip from Arlington to Mount Vernon it is assumed that the State of Virginia would readily cede its jurisdiction to the United States for such an undertaking. The cost of such right of way is so insignificant an item, that it is better to provide for all possible future contingencies at the beginning.

In the estimates 80 feet of road-bed has been assumed as the minimum that should be constructed, as it is important that all embankments should have ample time to settle and become compacted. A road-bed of 80 feet would admit of a driveway of 50 or 60 feet, and 15 or 10 feet of parking on each side of it. It is believed, however, that it would be preferable to make the road-bed 120 feet, with 60 feet for a drive and 30 feet of parking on each side, and estimates have been made for this also. The parking could be utilized in many ways over a part of the route. Within a short time it might be necessary to provide a traffic roadway to accommodate heavy teams.

The masonry bridges should be about 60 feet wide, as they will be permanent constructions not susceptible of increase in width.

The road covering should not be injurious to a horse's feet. At the same time it should give a smooth surface. Such a surface is furnished by what is known as the Telford covering. It consists of a paving of rough

stones about 8 inches deep. This is covered by about 6 inches of small broken stone, and this by about 4 inches of gravel, the latter put on in layers, screened and well rolled. The road should be well drained and provided with paved gutters on each side to convey surface water to the openings into drain pipes and culverts. Such a road, for pleasure driving, is perhaps the best that can be made. A gravel covering to the road-bed, carefully laid, about 15 inches deep, without the Telford paving, will make a good road for driving, and the cost can be very much reduced.

The estimates provide for either a Telford paving or one of gravel only. There is an abundance of good gravel throughout this entire section and no lack of other material to make good roads. The brick-yards along the river between Washington and Alexandria are of easy access, and can supply material for culverts and other constructions at reasonable rates. The surface of the country abounds in cobble-stones, which will supply good material for side gutters and can be broken up for road covering if needed.

By an arbitrary increase or diminution of grade the cost of construction on any route can be increased or diminished. In order, therefore, to make the estimates of cost on the various routes comparable one with another, a maximum grade had to be assumed. This maximum was fixed at 4.5 feet per 100. No steeper grade is provided for, and wherever it can be done without undue enhancement of the cost, the endeavor has been to keep the grade down to about 3 feet in 100. There are but few places on any route where the grade reaches the maximum. Where the land is level a grade of .50 foot in 100 has been given to secure drainage.

The alignments on the different routes were run to secure overhead crossings to all railroads where practicable. The valleys of Big Hunting Creek and Four-Mile Run, which have to be crossed, are occupied by the railroad tracks of the Washington and Ohio, Richmond and Danville, and Alexandria and Fredericksburg railroads. To cross these roads at grade would materally decrease the cost of construction, but grade crossings over railroads ought to be avoided, and overhead crossings have been provided for in all cases where it was practicable to do so.

The following is a description of the three main routes that were surveyed, together with eight others made up of parts of these three principal ones, with their connections. They make eleven in all, though some differ but little from each other:

(1) *The east or river route.*—Beginning at the south end of the Aqueduct Bridge it follows the bed of the abandoned Alexandria and Georgetown Canal to Alexandria; thence along Washington street to Big Hunting Creek, crossing the latter stream near the Alexandria brick-yards; thence along the low grounds east of the Accotink Pike to a point near Old Red House; thence bearing westward, it crosses Little Hunting Creek about a mile east of Gum Spring, and thence bears southward to Mount Vernon. From the Aqueduct Bridge to Prospect Hill, 2½ miles south of Alexandria, the route passes over a comparatively level country, and the grades are the minimum. From Prospect Hill to Mount Vernon the grades are easy, and in no case exceed 3 feet per 100. The alignment along the canal is somewhat tortuous, as the latter follows the natural contour as far as practicable. This route is low as far as Prospect Hill, and consequently has few fine views of the surrounding country. Two of the railroad crossings are on grade, which can not be avoided. It is the

line of minimum grades, passes through Alexandria, and is conveniently reached from the Long Bridge crossing of the Potomac.

The estimated cost over this route is as follows:

For a road-bed 80 feet wide, 60 feet Telford covering and 10 feet of parking on each side	$1,555,506
For the same road-bed and parking, but with 15 inches gravel covering	1,107,481
For a road-bed 120 feet wide, 60 feet Telford covering, and 30 feet of parking on each side	1,819,869
For same road-bed and parking, but with 15 inches gravel covering	1,371,844

These estimates do not include work within corporation limits of Alexandria, Va.

(2) The middle route begins at the south end of the Aqueduct Bridge, follows the general direction of the Georgetown and Alexandria road, east of the National Cemetery, crosses the Columbia pike at Johnson's store, and reaches a commanding point at old Fort Albany; thence the line passes along the crest of a narrow ridge, descending into the valley of Four-Mile Run by the route of the old Alexandria road, now abandoned. After crossing Four-Mile Run it ascends the ridge, crossing the Washington and Ohio Railroad overhead, and passes directly in front of Frank Hume's residence; thence across the Leesburgh pike, back of Shuter's Hill, where it descends into the valley of Hunting Creek, crossing the Richmond and Danville, and Alexandria and Fredericksburg railroads overhead; thence, bearing to eastward, the line crosses the gravel road to the Accotink pike, the general direction of which it follows to Gum Spring; thence it follows the ridge east of the public road, and nearly parallel to it, to Mount Vernon.

The grades from the Aqueduct Bridge to Fort Albany are light, in no case exceeding 3.6 feet per 100. To descend the valley of Four-Mile Run and to ascend the ridge south of that stream the maximum grade has been used; from there the grades are reasonably good, except at the deep ravine north of Shuter's Hill, at which place and at the crossing of the railroads the maximum gradient has been used. From Hunting Creek to Mount Vernon the grades are generally light, not exceeding 3 feet in 100. The alignment is fairly good, except on that portion lying between Four-Mile Run and Hunting Creek, where deep gullies indent the ridge and necessitate a more tortuous route.

The middle line, occupying for the most part the ridge adjacent to the river, affords an almost unbroken view of the latter from the Aqueduct Bridge to Prospect Hill. From there on, the scenery is of a rural character. By an increase in the maximum grade and proportional increase of cost this line could be carried over Shuter's Hill, from which one of the finest views of the river and surrounding country can be obtained. The railroads are all crossed overhead.

The estimated cost over this route is as follows:

For a road-bed 80 feet wide, 60 feet Telford covering and 10 feet of parking on each side	$1,468,436
For the same road-bed and parking, but with 15 inches gravel covering	977,160
For a road-bed 120 feet wide, 60 feet Telford covering and 30 feet of parking on each side	1,736,199
For the same road-bed and parking, but with 15 inches gravel covering	1,244,869

(3) The west route, beginning at the Aqueduct Bridge, follows the extension of Chadwick avenue, Rosslyn, for about 2,000 feet; thence up the valley of a small stream north of the National Cemetery, passing in front of the military post of Fort Myer, reaching an elevation of 235 feet above tide level; thence over a level plateau to the Columbia pike, after crossing which the line follows the general direction of the Fairfax Seminary road, descending the valley of Four-Mile Run and

crossing the Washington and Ohio Railroad overhead; thence it ascends the ridge south of the Run, in the valley of a small stream, and after reaching the summit passes over a wide plateau, crossing the Leesburgh pike near its junction with the Braddock road; thence it passes about 1,400 feet east of the Theological Seminary, and descends into the valley of Hunting Creek, crossing the tracks of the Richmond and Danville and Alexandria and Fredericksburg railroads overhead. The line then bears to southeastward till it reaches the valley of a small tributary of Hunting Creek; it then follows this valley, crossing the Gravel and the Mount Vernon roads just north of Spring Bank farm; it then follows the general direction of the Mount Vernon road southward, descending into the valley of Little Hunting Creek near the residence of Mr. Collard. From this point the line is nearly straight to Gum Spring, near which it unites with the middle route, and from thence to Mount Vernon the two are identical.

From the Aqueduct Bridge to Fort Myer the grades do not exceed 3 feet per 100. In the descent into the valley of Four-Mile Run and the ascent on the opposite side the grade is generally 3 feet per 100, but for a short part of the distance it is 4 feet per 100. Crossing the plateau east of the seminary the country is level and the minimum grade obtains. Descending the valley of Hunting Creek the grade is 4.5 feet per 100. South of that stream, as far as James Kirby's, the grades are light, not exceeding 2.7 feet per 100. In the descent into the valley of Little Hunting Creek the grade is 4.5 feet per 100 for a distance of 3,000 feet. From thence the grades are light.

The estimated cost over this route is as follows:

For a road-bed 80 feet wide, 60 feet Telford covering and 10 feet of parking on each side	$1,390,898
For the same road-bed and parking, but with 15 inches gravel covering	930,824
For a road-bed 120 feet wide, 60 feet Telford covering and 30 feet of parking on each side	1,661,047
For the same road-bed and parking, but with 15 inches gravel covering	1,200,973

The following is a summary of the estimates on the three principal routes, and eight others made up of parts of the three principal routes and intermediate connections. For a description of routes Nos. 1 to 8, inclusive, see report of Mr. Mackall, hereto appended.

Line.	For a road-bed 80 feet wide, 10 feet of parking on each side.			For a road-bed 120 feet wide, 30 feet of parking on each side.		
	Length.	Gravel roadway 60 feet.	Telford roadway 60 feet.	Length.	Gravel roadway 60 feet.	Telford roadway 60 feet.
	Miles.			*Miles.*		
East*	15.08	$1,107,481	$1,555,506	15.08	$1,371,844	$1,819,869
Middle	15.09	977,160	1,468,490	15.09	1,244,869	1,736,199
West	14.13	930,824	1,390,898	14.13	1,200,973	1,661,047
No. 1*	15.37	984,447	1,441,915	15.37	1,217,902	1,675,370
No. 2*	14.63	953,405	1,386,453	14.63	1,059,682	1,514,730
No. 3	13.77	1,037,556	1,485,907	13.77	1,308,278	1,756,629
No. 4	14.68	1,063,513	1,541,493	14.68	1,296,221	1,774,202
No. 5*	15.30	1,066,257	1,532,210	15.30	1,341,041	1,806,995
No. 6	15.28	1,072,129	1,569,646	15.28	1,319,236	1,816,753
No. 7	15.59	1,012,314	1,519,925	15.59	1,294,022	1,801,632
No. 8	16.20	1,074,239	1,601,711	16.20	1,366,972	1,894,444

*Estimate includes no work within the corporation limits of Alexandria, Va.

It will be noticed that there is comparatively little difference in the estimated cost of construction over any of the routes enumerated, so that practically this question is one of minor consideration. I have en-

deavored to supply such information in regard to all as will enable Congress to decide as to which is the most desirable.

Attention is invited to the fact that the eastern route passes through the city of Alexandria, along the line of Washington street. In the estimates nothing has been provided to be done within the corporate limits of that city, as it is not known what the authorities of the city would do in regard to the portion of the route within its jurisdiction. The survey was carried through the city in compliance with the earnest wish of the members of the Mount Vernon Avenue Association, and in order to supply estimates covering all practicable routes. The legal and other questions involved in locating a route through Alexandria have not been considered.

The State of Virginia has already taken preliminary steps looking to the construction of a road from Washington City to Mount Vernon by granting a charter to a corporation known as the Mount Vernon Avenue Association. This association has power to acquire the right of way for an avenue 200 feet wide by condemnation, donation, or purchase, and to conduct and keep in repair a public avenue or highway thereon and to adorn and beautify the same. The State of Virginia has also transferred to the said association a claim against the General Government for $120,000—money said to have been advanced by the State in 1790 toward the completion of certain public buildings in Washington, D. C. A copy of the charter referred to and the act of the State of Virginia transferring its claim for the $120,000 is appended hereto.

I transmit herewith a copy of the report (appended) of Mr. Mackall, together with maps and drawings as follows:

1. Map of a portion of Alexandria and Fairfax Counties, Va., showing routes surveyed.
* 2. Profile of west route.
* 3. Profile of middle route.
* 4. Profile of east route.
* 5. Four profiles of auxiliary connecting lines.
* 6. Cross-section of proposed roadway, 80 feet wide.
* 7. Cross-section of proposed roadway, 120 feet wide.
* 8. Sketch of proposed bridge over Washington and Ohio Railroad, west route.
* 9. Sketch of proposed bridge over the Alexandria and Fredericksburg and Richmond and Danville Railroads.
* 10. Sketch of proposed bridge over Hunting Creek, west route.
* 11. Sketch of proposed bridge over Hunting Creek, east route.

Very respectfully, your obedient servant,

PETER C. HAINS,
Lieutenant-Colonel, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A., Washington, D. C.

REPORT OF MR. B. F. MACKALL.

WASHINGTON, D. C., *December* 18, 1889.

COLONEL: I have the honor to make the following report of the surveys made under your supervision for a national roadway from Washington City to Mount Vernon.

The field-work was begun on May 10, the party going into camp on the 17th of that month. The work was pushed forward as rapidly as possible, but, owing to the unprecedented rain-fall during the spring and summer, was not completed until the 17th of September, 1889.

Starting at the south end of the Aqueduct Bridge, three principal

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*Omitted.

lines were surveyed to Mount Vernon, namely: The east or river route, the middle, and the west, the distance between the outer lines being about 3 miles. The topography of the country and increase of distance made a more western survey unnecessary. In addition to the above, numerous short surveys were made connecting the principal lines at various points and forming with them continuous lines to Mount Vernon. Upon several of the more important of these combined lines estimates have been made. The topography of the country was accurately taken in the vicinity of the lines, the principal streams, highways, railroad crossings, and other important features carefully located. The names of property owners and, as far as could be ascertained, the boundaries of their lands were taken, the contours and other details being obtained from the U. S. Coast Survey map and checked wherever possible. The instruments used in the field-work were a transit and "Y" level, the measurement being made with a 100-foot chain, and steel tape when greater accuracy was required. The transit lines were accurately and carefully run, with the view of obtaining close preliminary lines on which to base the estimated cost of construction. Mean low water of the bench-mark near Easby's Point was taken as the reference of all elevations. Elevations were taken over all the lines, and bench-marks established at intervals of 1,000 feet, so that accurate profiles could be obtained, the total error in elevation of the sun-dial at Mount Vernon, as established by the various lines of levels, being .07 of a foot. Where the country was rough and broken elevations were taken at right angles to the lines, and upon these cross-sections the estimates for the 80-foot road-bed are based. In estimating for the 120-foot road-bed it was found that an average cross-section, supposing the ground level or having a uniform slope, would require an increase of about 40 per cent., but owing to the fact that in many instances the ground was very rough it has been thought safer to use 50 per cent.

The country covered by the surveys is generally rough and broken. The long ridge, rising about 200 feet above tide, which skirts the west bank of the river, is indented by deep ravines and broad valleys. The lowlands between this ridge and the river, extending from the Aqueduct Bridge to Prospect Hill, 2½ miles south of Alexandria, offer substantially a level surface for the proposed avenue. The geological formation is principally coarse gravel mixed with clay or sand, overlying a strata of compact clay; beneath this clay, at a great depth, there is a coarse, perishable sandstone, outcropping just north of Mount Vernon. From the nature of the formation, in seasons of continued rain the upper strata of porous sand and gravel will have a tendency to slide upon the underlying clay. South of Hunting Creek, along the river, there are unmistakable evidences of such slides having taken place. Just north of the Mount Vernon mansion a slide took place last spring and summer, and, from actual observations, moved at the rate of 10 feet per month, glacier-like, carrying everything before it. Inland from the river there appears no evidence of slides having taken place in recent years.

As the basis for the estimated cost a maximum gradient of 4.5 feet per 100 and a minimum of .50 foot per 100 have been adopted. The preliminary lines have been run with the view of crossing the several railroads above or below grade wherever possible, believing that the increase of traffic of the railroads and the avenue, if constructed, would render crossings at grade out of the question, however inexpensive.

Two estimates have been made of each of the several lines, viz: For an 80-foot road-bed—60 feet of Telford roadway with 10 feet of parking

on each side. (2) A 120-foot road-bed—60 feet of Telford roadway and 30 feet of parking on each side. From the formation of the country and the absence of all indications of rock, but two classes of material have been estimated upon, viz: Earth and stiff clay, the former at 30 cents per cubic yard and the latter at 50 cents, the cost of moving to include an average haul of 500 feet, the limit of free haul being taken at 200 feet. On account of a probable restricted right of way, borrowed material has been estimated at 40 cents per cubic yard, as material other than earth may have to be used. The prices for masonry, brick or stone, include the cost of cement, sand, and construction. The prices for excavation, embankment, the cost of construction of masonry, etc., are based on the cost of work of like character on the several railroads of the country, and it is believed that any of the lines can be constructed within the estimates at the present cost of labor and material.

In order to avoid repetition as far as possible only a general description of the three principal lines is given, and of the combined lines wherever they differ materially from those already described.

The various lines of survey for the Mount Vernon avenue have been designated in the field-notes by certain letters of the alphabet, and this nomenclature has been used for the profiles of the same. Thus A, or the middle, line extends from the Aqueduct Bridge to Mount Vernon. C line from station 10 plus 80 A line, by Fort Myer to station 131 plus 54 A line. E line from station 225 A line to station 93 N line. F line from station 233 A line, through Alexandria, to station 453 A line. H line from station 68 plus 80 C line to station 716 A line. I line from station 178 plus 30 H line to station 323 A line. K line from station 78 plus 60 H line to station 146 plus 97 H line. N line from station 26 plus 30 F line to station 211 plus 65 F line. O line from station 465 A line to station 552 A line. P line from station 211 plus 65 F line to station 435 plus 60 H line. R line from station 415 A line to station 335 H line. S line from station 300 A line to station 397 A line. T line from station 465 plus 60 H line to station 499 H line. V line from station 540 A line to station 777 A line. X line from station 453 A line to station 84 V line. Y line from station 235 V line to station 815 plus 50 A line.

THE EAST LINE.

Beginning at the south end of the Aqueduct Bridge it follows the bed of the old Alexandria and Georgetown Canal to Washington street, Alexandria (station 106 plus 40 F line of the field-notes); thence with that street produced to station 3 (X line of the field-notes); thence along the lowlands, between the river and Accotink pike to station 157 plus 93; thence bearing west it crosses Little Hunting Creek about 1 mile below Gum Spring, uniting with the middle line at station 777; thence by the middle line to Mount Vernon. From the Aqueduct Bridge to Prospect Hill, 2½ miles south of Hunting Creek, the country is comparatively level, and the grades correspondingly light. From thence to Mount Vernon in no instance will they exceed 3 feet per 100, and are generally far below that gradient. Excepting certain portions of the canal, which is more or less winding, the alignment is excellent. Portner's switch and the Baltimore and Ohio track in Alexandria are crossed at grade.

ESTIMATE FOR EAST LINE. LENGTH 15.08 MILES.

[For a road-bed 80 feet wide, 60 feet of Telford roadway with 10 feet of parking on each side.]

454,000 cubic yards of earth excavation, at 30 cents	$136,200
80,000 cubic yards of stiff clay excavation, at 50 cents	40,000
400,000 cubic yards borrowed excavation, at 40 cents	160,000
2,180 cubic yards brick masonry, at $12	26,160
2,100 cubic yards stone masonry, at $12	25,200
260 cubic yards paving (1 foot deep, for culverts), at $4	1,040
30 cubic yards ring stone (masonry), at $20	600
Arch bridge over Washington and Alexandria Railroad (masonry)	40,000
Arch bridge over Hunting Creek (masonry)	136,600
Arch bridge over Little Hunting Creek (masonry)	58,200
40,000 cubic yards of riprap, at $1	40,000
16,000 square yards slope paving, at $2	32,000
49,000 square yards mattresses, at 45 cents	22,050
89,900 cubic yards Telford base, at $2.50	224,750
66,400 cubic yards broken stone, at $1.75	116,200
44,900 cubic yards gravel, at $1	44,900
38,600 cubic yards sand or gravel, at 80 cents	30,880
145,550 linear feet curbing, at 90 cents	130,995
80,850 square yards paving (gutters), at 50 cents	40,425
71,500 cubic yards top soil (parking), at 20 cents	14,300
13.76 miles drainage, at $3,700	50,912
4,840 trees, at $1	4,840
378.45 acres land, at $100	37,845
	1,414,097
Engineering and supervision, 10 per cent	141,409
Total	1,555,506
The same with 60-foot gravel roadway	1,107,481

This estimate does not include 7,000 feet through the corporation limits of the city of Alexandria.

[For a road-bed 120 feet wide, 60 feet of Telford roadway with 30 feet of parking on each side.]

680,000 cubic yards earth excavation, at 30 cents	$204,000
120,000 cubic yards stiff clay excavation, at 50 cents	60,000
600,000 cubic yards borrowed excavation, at 40 cents	240,000
3,052 cubic yards brick masonry, at $12	36,624
2,940 cubic yards stone masonry, at $12	35,280
364 cubic yards of paving (1 foot deep, for culverts), at $4	1,456
30 cubic yards ring stone (masonry), at $20	600
Arch bridge over Washington and Alexandria Railroad	40,000
Arch bridge over Hunting Creek	136,600
Arch bridge over Little Hunting Creek	58,200
40,000 cubic yards riprap, at $1	40,000
16,000 square yards slope paving, at $2	32,000
60,000 square yards mattresses, at 45 cents	27,000
89,900 cubic yards Telford base, at $2.50	224,750
66,400 cubic yards broken stone, at $1.75	116,200
44,900 cubic yards gravel, at $1	44,900
38,600 cubic yards sand or gravel, at 80 cents	30,880
145,550 linear feet curbing, at 90 cents	130,995
80,850 square yards paving (gutters), at 50 cents	40,425
143,000 cubic yards top soil (parking), at 20 cents	28,600
27,700 cubic yards gravel (sidewalks), at $1	27,700
13.76 miles of drainage, at $3,700	50,912
9,460 trees, at $1	9,460
378.45 acres land, at $100	37,845
	1,654,427
Engineering and supervision, 10 per cent	165,442
Total	1,819,869
The same with 60 foot gravel roadway	1,371,844

This estimate does not include 7,000 feet through the corporation limits of the city of Alexandria.

THE MIDDLE LINE.

Begins at the Aqueduct Bridge and follows the general direction of the public road east of the National Cemetery to station 131, Fort Albany. Thence along the narrow ridge between the river and north branch, descending by the old military road to the valley of Four Mile Run to station 233, from which point branch lines pass through and back of Alexandria. From station 233 the line ascends the ridge passing in front of Mr. Hume's residence. Thence across the Leesburgh pike, west of Shuter's Hill, it descends to the valley of Hunting Creek, crossing the Little River pike and the tracks of the Richmond and Danville, and Alexandria and Fredericksburg railroads near the Episcopal Chapel. Thence bearing eastward, crossing the gravel road near Oliver Pullman's to station 453 on the Accotink pike. Thence with the general direction of said pike to Gum Spring. From Gum Spring the line takes the ridge just east of the public road and parallel with it to station 796, the north boundary of the Mount Vernon Association's property. From this point the line was extended to the Mansion House, the estimates being made out only to station 796, the aforesaid boundary. From station 465 to station 552, two lines were surveyed up Prospect Hill. The one on which the estimates are based, to the west of the pike, is 300 feet longer, but has the advantage in grade. From the Aqueduct Bridge to station 180, the grades are generally good, for a short distance 3.6 feet per 100 being used to ascend the ridge to Fort Albany. The descent into the valley of Four Mile Run, and the ascent south, the maximum grade of 4.5 feet per 100 has been used. Thence to Hunting Creek the grades are reasonably good, with the exception of the maximum grade at the crossing of the several railroad tracks and the deep ravine back of Shuter's Hill. From Hunting Creek to Mount Vernon the grades are light and need not exceed 3 per cent., about that gradient being required to ascend and descend the ridge at Prospect Hill and the ridge south of Gum Spring. The alignment is generally good, except from Four Mile Run to the Little River pike, where, owing to improved property, the cemetery back of Shuter's Hill, and other obstacles, the preliminary line is more or less tortuous. All railroads are crossed overhead.

ESTIMATE FOR MIDDLE LINE. LENGTH, 15.09 MILES.

[For a road-bed 80 feet wide, 60 feet Telford roadway, with 10 feet of parking on each side.]

500,000 cubic yards earth excavation, at 30 cents	$150,000
128,000 cubic yards stiff clay excavation, at 50 cents	64,000
223,000 cubic yards borrowed excavation, at 40 cents	89,200
3,300 cubic yards brick masonry, at $12	39,600
4,940 cubic yards stone masonry, at $12	59,280
730 cubic yards paving (1 foot deep, for culverts), at $4	2,920
60 cubic yards ring stone (masonry), at $20	1,200
Arch bridge over Four-Mile Run (masonry)	41,000
Arch bridge over Washington and Ohio Railroad (masonry)	30,000
Arch bridge over Richmond and Danville and Alexandria and Fredericksburg railroads (masonry)	43,000
Arch bridge over Hunting Creek (masonry)	50,000
98,400 cubic yards Telford base, at $2.50	246,000
73,800 cubic yards broken stone, at $1.75	129,150
49,200 cubic yards gravel, at $1	49,200
42,252 cubic yards sand or gravel, at 80 cents	33,802
159,400 linear feet curbing, at 90 cents	143,460
88,600 square yards paving (gutters), at 50 cents	44,300
78,700 cubic yards top-soil (for parking), at 20 cents	15,740

15.09 miles of drainage, at $3,700	$55,833
5,310 trees, at $1	5,310
419.96 acres land, at $100	41,996
	1,334,991
Engineering and supervision, 10 per cent	133,499
Total	1,468,490
The same with 60 feet gravel roadway	977,160

[For a road-bed 120 feet wide, 60 feet of Telford roadway, with 30 feet of parking on each side.]

750,000 cubic yards earth excavation, at 30 cents	$225,000
192,000 cubic yards stiff clay excavation, at 50 cents	96,000
334,000 cubic yards borrowed excavation, at 40 cents	133,600
4,620 cubic yards brick masonry, at $12	55,440
6,916 cubic yards stone masonry, at $12	82,992
1,020 cubic yards paving (1 foot deep, for culverts), at $4	4,080
60 cubic yards ring stone (masonry), at $20	1,200
Arch bridge over Four Mile Run (masonry)	41,000
Arch bridge over Washington and Ohio Railroad (masonry)	30,000
Arch bridge over Alexandria and Fredericksburg and Richmond and Danville railroads (masonry)	43,000
Arch bridge over Hunting Creek (masonry)	50,000
96,400 cubic yards Telford base, at $2.50	246,000
73,800 cubic yards broken stone, at $1.75	129,150
49,200 cubic yards gravel at $1	49,200
42,252 cubic yards sand or gravel, at 80 cents	33,802
159,400 linear feet curbing, at 90 cents	143,460
88,600 square yards paving (for gutters), at 50 cents	44,300
157,400 cubic yards top-soil (for parking), at 20 cents	31,480
30,200 cubic yards gravel (for sidewalks), at $1	30,200
15.09 miles of drainage, at $3,700	55,833
10,630 trees, at $1	10,630
419.96 acres of land, at $100	41,996
	1,578,363
Engineering and supervision, 10 per cent	157,836
Total	1,736,199
The same with 60 feet gravel roadway,	1,244,869

THE WEST LINE.

Beginning at the Aqueduct Bridge the west line follows Chadwick Avenue (Rosslyn) produced, thence up the valley of a small stream north of the National Cemetery to Fort Myer, reaching an elevation of 235 feet at station 7 (H line of the field-notes). From Fort Myer the line is perfectly straight to station 78 plus 60, south of the Columbia pike. To descend into the valley of Four Mile Run two lines were surveyed, uniting at station 146 plus 97. The first, straight down the bluff, was more direct by 350 feet, but requiring a steeper grade by 1 foot per 100. The second, upon which the estimates are based, follows the general direction of the Fairfax Seminary road. Ascending the ridge south of Four Mile Run the line crosses the Leesburgh pike near its junction with the Braddock road, and, passing east of the Seminary, it descends to the valley of Hunting Creek. Thence from Hunting Creek, bearing eastward, the line ascends the valley of a small stream near Peter Pullman's, crossing the gravel and Mount Vernon roads near Spring Bank farm. Thence with the general direction of the Mount Vernon road, on the east side, it descends the ridge near Collard's to the valley of Little Hunting Creek. Thence to Gum Spring the line is practically straight, uniting with the middle line at station 716, just south of that stream. Thence with the middle line to Mount Vernon as before described.

From the Aqueduct Bridge to Fort Myer the grades do not exceed 3 feet per 100. Thence as far as the Seminary road the minimum grade is generally used. The descent into the valley of Four Mile Run, and the ascent south, 3 feet per 100 can be obtained. For a short distance 4 feet per 100 has been used. Across the plateau east of the seminary the grades are very easy. The descent to the valley of Hunting Creek the maximum grade is used. Thence as far as the ridge at Collard's the grades do not exceed 2.7 feet per 100. The ridge breaking off suddenly to the eastward the descent into the valley of Little Hunting Creek is abrupt, and the maximum grade has been used for nearly 3,000 feet. To obviate this a preliminary line was surveyed around the hill, increasing the distance but giving a lower gradient. Across the valley of Little Hunting Creek to Mount Vernon the grades are excellent. The alignment throughout is fairly good. All railroads are crossed overhead.

ESTIMATE FOR WEST LINE. LENGTH 14.13 MILES.

[For a road-bed 80 feet wide, 60 feet Telford roadway, with 10 feet of parking on each side.]

504,000 cubic yards earth excavation, at 30 cents	$151,200
134,000 cubic yards stiff clay excavation, at 50 cents	67,000
156,000 cubic yards borrowed excavation, at 40 cents	62,400
4,350 cubic yards brick masonry, at $12	52,200
7,300 cubic yards stone masonry, at $12	87,600
800 cubic yards paving (1 foot deep, for culverts), at $4	3,200
70 cubic yards ring stone (masonry), at $20	1,400
Arch bridge over Washington and Ohio Railroad (masonry)	39,000
Arch bridge over Alexandria and Fredericksburg and Richmond and Danville railroads (masonry)	42,900
Arch bridge over Hunting Creek (masonry)	41,000
92,200 cubic yards Telford base, at $2.50	230,500
69,100 cubic yards broken stone, at $1.75	120,925
46,100 cubic yards gravel, at $1	46,100
39,570 cubic yards sand or gravel, at 80 cents	31,656
149,300 linear feet curbing, at 90 cents	134,370
82,900 square yards paving (for gutters), at 50 cents	41,450
73,800 cubic yards top soil (for parking), at 20 cents	14,760
14.13 miles of drainage, at $3,700	52,281
5,000 trees, at $1	5,000
395.11 acres of land, at $100	39,511
	1,264,453
Engineering and supervision, 10 per cent	126,445
Total	1,390,898
The same with 60 feet gravel roadway	930,824

[For a road-bed 120 feet wide, 60 feet of Telford roadway, with 30 feet of parking on each side.]

756,000 cubic yards earth excavation, at 30 cents	$226,800
201,000 cubic yards stiff clay excavation, at 50 cents	100,500
234,000 cubic yards borrowed excavation, at 40 cents	93,600
6,090 cubic yards brick masonry, at $12	73,080
10,220 cubic yards stone masonry, at $12	122,640
1,120 cubic yards paving (1 foot deep for culverts), at $4	4,480
70 cubic yards ring stone (masonry), at $20	1,400
Arch bridge over Washington and Ohio Railroad (masonry)	39,000
Arch bridge over Alexandria and Fredericksburg and Richmond and Danville railroads (masonry)	42,900
Arch bridge over Hunting Creek (masonry)	41,000
92,200 cubic yards Telford base, at $2.50	230,500
69,100 cubic yards broken stone, at $1.75	120,925
46,100 cubic yards gravel, at $1	46,100
39,571 cubic yards sand or gravel, at 80 cents	31,656
149,300 linear feet curbing, at 90 cents	134,370
82,900 square yards paving (for gutters), at 50 cents	41,450

148,000 cubic yards top-soil (for parking), at 20 cents	$29,600
28,300 cubic yards gravel, (for side-walks), at $1	28,300
14.13 miles of drainage, at $3,700	52,281
9,950 trees, at $1	9,950
395.11 acres of land, at $100	39,511
	1,510,043
Engineering and supervision, 10 per cent	151,004
Total	1,661,047
The same with 60 feet gravel roadway	1,200,973

LINE NO. 1.

Begins at the Aqueduct Bridge and follows the east line through Washington street, Alexandria, to station 456 of the middle line south of Hunting Creek, thence by the middle line to Mount Vernon. The maximum grade is about 3 per cent., and the alignment fairly good. The Baltimore and Ohio Railroad and Portner's Switch are crossed at grade.

ESTIMATES.

For 80 feet of road-bed, with 60 feet Telford paving	$1,441,915
For 120 feet of road-bed, with 60 feet Telford paving	1,675,370
For 80 feet of road-bed, with 60 feet gravel	984,447
For 120 feet of road-bed, with 60 feet gravel	1,217,902

LINE NO. 2.

Beginning at the Aqueduct Bridge, follows the east line to Jefferson street, Alexandria, crossing Hunting Creek near the site of the present bridge, thence up Spring Bank Run, east of the gravel road, to station 435 plus 60 of the west line; thence with the west line to Mount Vernon. The grades and alignment are those of the east and west lines as before described. The valley of Spring Bank Run is of very easy ascent, not requiring over 3 feet per 100. The Baltimore and Ohio Railroad and Portner's Switch are crossed at grade.

ESTIMATES.

For 80 feet of road-bed, with 60 feet Telford paving	$1,386,453
For 120 feet of road bed, with 60 feet Telford paving	1,514,730
For 80 feet of road-bed, with 60 feet gravel	953,405
For 120 feet of road-bed, with 60 feet gravel	1,059,682

LINE NO. 3.

Begins at the Aqueduct Bridge, thence with the middle line to station 233, thence back of Alexandria, near the National Cemetery, to station 7 plus 50 (P line of the field notes), thence up the valley of Spring Bank Run, east of the gravel road to station 435 plus 60 of the west line, thence with the west line to Mount Vernon. All railroads are crossed under or above grade. The grades and alignment are those of the middle and west lines. From station 233 of the middle line to station 7 plus 50, P line, the country is comparatively level.

ESTIMATES.

For 80 feet of road-bed, with 60 feet Telford paving	$1,485,907
For 120 feet of road-bed, with 60 feet Telford paving	1,756.629
For 80 feet of road-bed, with 60 feet gravel	1,037,556
For 120 feet of road bed, with 60 feet gravel	1,308,278

LINE NO. 4.

Begins at the Aqueduct Bridge, thence with the middle line to station 233, thence back of Alexandria, near the National Cemetery, to station 453 of the middle line, thence by the middle line to Mount Vernon. All railroads are crossed under or above grade. The grades and alignment are those of the middle line, excepting from station 233 to station 453, over a comparatively level country, and need not exceed 3 feet per 100.

ESTIMATES.

For 80 feet of road-bed, with 60 feet Telford paving	$1,541,493
For 120 feet of road-bed, with 60 feet Telford paving	1,774,202
For 80 feet of road-bed, with 60 feet gravel	1,063,513
For 120 feet of road-bed, with 60 feet gravel	1,296,221

LINE NO. 5.

Begins at the Aqueduct Bridge, follows the middle line to station 233, thence by St. Asaph's Junction, through Washington Street, Alexandria, to Station 453 of the middle line, thence by the middle line to Mount Vernon. The railroads at St. Asaph's Junction, Portner's Switch, and the Baltimore and Ohio tracks are all crossed at grade. The grades and alignment do not differ materially from line No. 4.

ESTIMATES.

For 80 feet of road-bed, with 60 feet Telford paving	$1,532,210
For 120 feet of road-bed, with 60 feet Telford paving	1,806,995
For 80 feet of road-bed, with 60 feet gravel	1,066,257
For 120 feet of road-bed, with 60 feet gravel	1,341,041

LINE NO. 6.

Beginning at the Aqueduct Bridge, follows the middle line to station 540, Prospect Hill, thence along the ridge between the river and the Accotink pike to station 158 of the east line, thence with the east line to Mount Vernon. The grades and alignment differ but little from the middle line. All railroads are crossed overhead.

ESTIMATES.

For 80 feet of road-bed, with 60 feet Telford paving	$1,569,646
For 120 feet of road-bed, with 60 feet Telford paving	1,816,753
For 80 feet of road-bed, with 60 feet gravel	1,072,129
For 120 feet of road-bed, with 60 feet gravel	1,319,236

LINE NO. 7.

Beginning at the Aqueduct Bridge follows the west line to Fort Myer, thence along the ridge west of the National Cemetery to Fort Albany, station 131, of the middle line, thence with that line to Mount Vernon. The only difference between this line and the middle line is that the former passes by Fort Myer. All railroads are crossed overhead.

ESTIMATES.

For 80 feet of road-bed, with 60 feet Telford paving	$1,519,925
For 120 feet of road-bed, with 60 feet Telford paving	1,801,632
For 80 feet of road-bed, with 60 feet gravel	1,012,314
For 120 feet of road-bed, with 60 feet gravel	1,294,022

LINE NO. 8.

Beginning at the Aqueduct Bridge follows the west line to station 335, south of Hunting Creek, thence along south side of said stream to station 415 of the middle line, thence with the middle line to station 540, Prospect Hill, thence along the ridge between the river and Accotink pike to station 158 of the east line, thence with that line to Mount Vernon. The grades and alignment are those of the various lines of which it is composed, heretofore described. All railroads are crossed overhead.

ESTIMATES.

For 80 feet of road-bed, with 60 feet Telford paving	$1,601,711
For 120 feet of road-bed, with 60 feet Telford paving	1,894,444
For 80 feet of road-bed, with 60 feet gravel	1,074,239
For 120 feet of road-bed, with 60 feet gravel	1,366,972

Very respectfully, your obedient servant,

B. F. MACKALL.

Lieut. Col. PETER C. HAINS,
Corps of Engineers, U. S. Army.

CHARTER OF THE MOUNT VERNON AVENUE ASSOCIATION.

AN ACT to incorporate the Mount Vernon Avenue Association.

1. *Be it enacted by the general assembly of the State of Virginia*, That John B. Smoot, E. W. Fox, Jefferson Chandler, M. B. Harlow, E. F. Beale, Jackson E. Sickles, Frank A. Reed, N. W. Pearson, Stacy Snowden, J. T. Beckham, W. E. Clarke, F. R. Windsor, Park Agnew, Frank Hume, George Johnston, Warrington Gillingham, H. A. Willard, W. M. Galt, Doctor G. Wythe Cooke, D. A. Windsor, Harrison Hatch, R. Portner, Walter Walton, Rozier Dulaney, H. H. Wells, L. L. Blake, R. L. Lacy, Captain Lawton, Francis Hufty, C. E. Stewart, J. Norman Gibbs, James M. Love, and James W. Roberts are hereby made and constituted a corporation and body politic, with power to increase the same, under the name and style of the Mount Vernon Avenue Association, by which name this corporation shall be known, and under which it may sue and be sued, contract and be contracted with, within the scope of its power as a corporation, and shall have perpetual succession.

2. Said corporation shall have the power to acquire right of way by condemnation, donation, or purchase for a public avenue and highway, not exceeding two hundred feet in width, from a point south of the Aqueduct Bridge or the northern boundary of the Government park, reservation, or cemetery, known as Arlington, on the Potomac River; thence through the county and city of Alexandria, passing through Washington Street of the said city of Alexandria, and through the county of Fairfax to the grounds inclosing the tomb of Washington, known as Mount Vernon, over the most practicable route to be selected by the trustees of said corporation, and to conduct and keep in repair a public avenue and highway thereon, and to adorn and beautify the same.

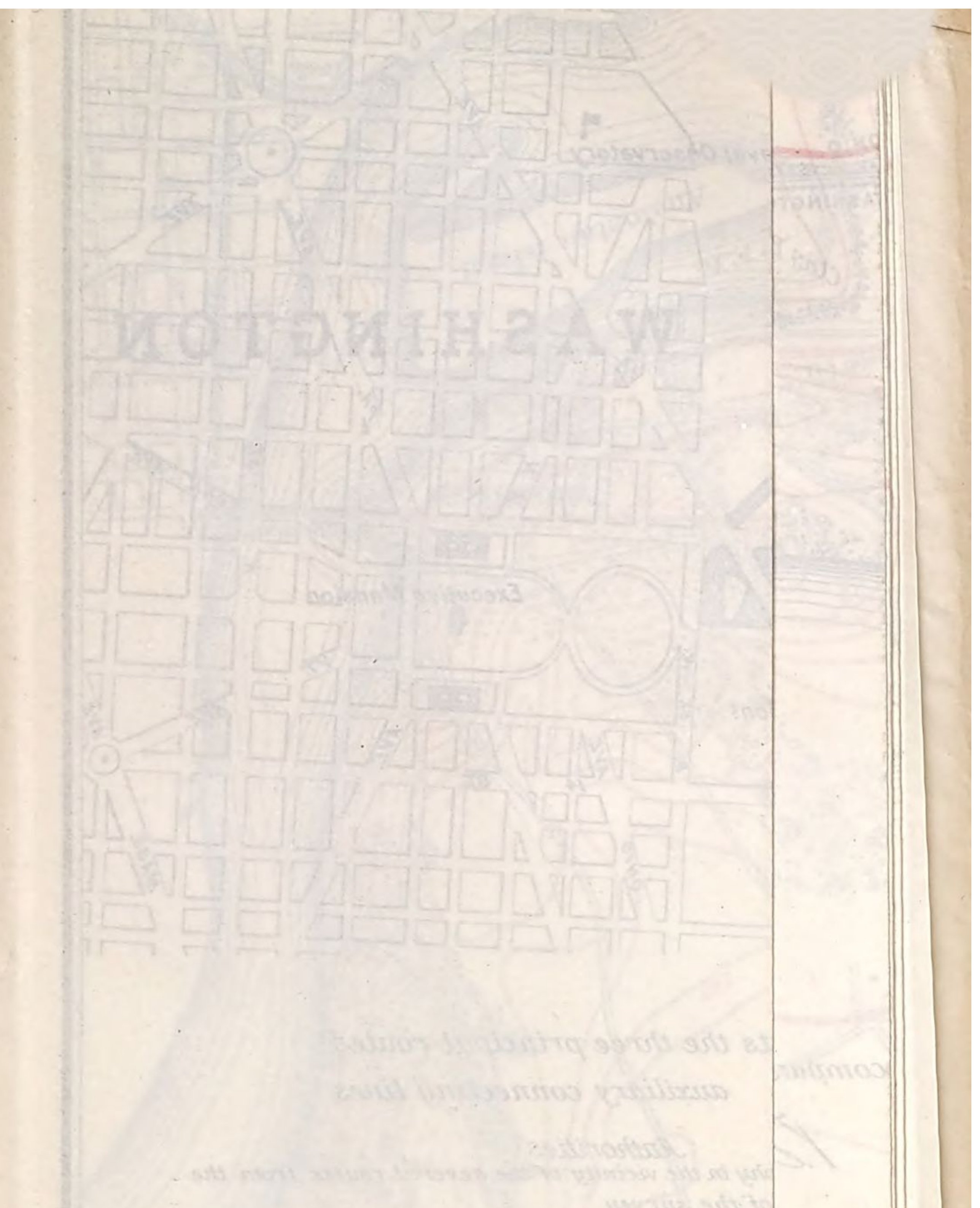
3. Said corporation shall be governed by the trustees herein named, a majority of whom shall constitute a quorum, and their successors in office. The said trustees, or quorum thereof, shall have power to fill all vacancies happening in their number by death, resignation, or otherwise.

4. Said association shall have power to receive subscriptions or contributions from the United States, the State of Virginia, or any State or Territory of the United States, or any county, corporation, person, or municipality thereof, to promote the accomplishment of the objects of this association.

5. Whatever is received by the association, from any source shall, without compensation to the trustees herein provided for, be expended to open, construct, build, keep in repair, and beautify the said avenue, and for such other charges as the said trustees may approve and determine.

6. The city of Alexandria is hereby authorized to aid the construction of said avenue in the city of Alexandria to the amount of twenty-five thousand dollars, to be paid either in cash or in the bonds of said city, as the city of Alexandria shall elect.

7. The counties of Alexandria and Fairfax are hereby, and each of them is, au-



MOUNT VERNON

thorized to aid in the construction of said avenue, by issuing their respective bonds not exceeding two thousand dollars for each county per mile of said avenue, or by contributing the same amount in cash.

8. The said corporation shall have power to condemn land, as the power to condemn for public use is now defined and exercised for public purposes under and by virtue of the general laws of the State of Virginia, and in exercising said power in condemning lands for said avenue and highway, advantages and benefits accruing to the owner of adjoining lands whose land is condemned for said avenue and highway, by virtue of the increase in value of said adjoining lands, shall be considered and deducted from any damage which said party may sustain by virtue of the condemnation proceedings herein contemplated for the purpose of establishing said avenue or highway.

9. Said trustees are hereby authorized to permit, under restrictions, regulations, conditions, and terms as said trustees, or a quorum thereof, deem advisable, such means of carrying passengers over said avenue as will not disturb the enjoyment of said avenue by ordinary private vehicles and carriages and means of travel; provided steam shall not be used as a motive power for carrying passengers.

10. This association shall have jurisdiction and authority to keep the peace on and over the said avenue, and power to appoint special policemen with the advice and consent of the judge of the county or corporation courts in whose jurisdiction they shall be employed, and said policemen shall have and exercise the same powers now or hereafter conferred upon constables and municipal police officers conferred by the laws of the Commonwealth of Virginia.

11. Said trustees shall make to the government of Virginia a detailed annual report of the receipts and expenditures of this association.

12. The principal office of this association shall be in the city of Alexandria, and its annual meetings shall be held in said city on the last Tuesday in the month of May in each year.

13. All taxes, dues, or demands due the State, or to become due by this company to the State of Virginia, shall be paid in lawful currency of the United States, and not in coupons.

14. This act shall be in force from its passage.

Approved February 18, 1883.

JOINT RESOLUTION transferring a certain claim of the State of Virginia against the Government of the United States to the Mount Vernon Avenue Association, chartered by this State.

Whereas, by an act of the general assembly of this State, passed December twenty-seventh, seventeen hundred and ninety, there was loaned by this State to the United States the sum of one hundred and twenty thousand dollars, to be applied towards the erection of the public buildings at the permanent seat of the Government of the United States, which said money so loaned by this State was paid in person to the then President of the United States, General George Washington, and disbursed under his supervision for the purpose for which it was loaned; and

Whereas, by resolution number five, adopted by this assembly March fifteenth, eighteen hundred and fifty (acts of assembly of Virginia, eighteen hundred and forty-nine–fifty, page two hundred and thirty-five), the claim of this State against the United States for the return of said loan was transferred to the Orange and Alexandria Railroad Company under certain conditions and with power to said company to demand and receive the same and the interest thereon; and

Whereas, the said claim having remained in the hands of said railroad company for nearly twenty-eight years without an appropriation by the Congress of the United States to pay the same, and the said company having become insolvent, this assembly, by its joint resolution approved February twentieth, eighteen hundred and seventy-eight (acts of assembly of Virginia, eighteen hundred and seventy-seven-seventy-eight, chapter sixty-nine, page sixty), repealed the said resolution adopted March fifteenth, eighteen hundred and fifty, transferring said claim to said railroad company, and requested, by said resolution of February twentieth, eighteen hundred and seventy-eight, the Senators and Representatives of this State in the United States Congress to exert their best efforts to recover the amount of the claim aforesaid; and

Whereas, this State, by its act of assembly passed during its present session, has lately granted a charter to the Mount Vernon Avenue Association, the object of which is to make an avenue or road to the tomb of General George Washington, as specified in the said charter; and

Whereas, the said claim, now nearly one hundred years old, never having been paid, and this assembly deeming the objects of the charter to said Mount Vernon Avenue Association worthy of patriotic approval, and considering that the said one hundred and twenty thousand dollars was paid to, handled, and disbursed under the

supervision of General George Washington, to whose tomb said avenue will lead: Therefore be it

1. *Resolved by the general assembly*, That the said claim of one hundred and twenty thousand dollars of this State against the United States, growing out of the loan aforesaid, under the act of this assembly passed December twenty-seventh, seventeen hundred and ninety, be, and the same is hereby, transferred to the said Mount Vernon Avenue Association, chartered as aforesaid by this State, and that said Mount Vernon Avenue Association be, and is hereby, empowered to demand, collect, and receive the said claim, and the interest thereon, from the Government of the United States; and when recovered or received from the United States the said Association shall pay, from the gross amount so recovered or received by it, to the special agent of this State, appointed by the governor thereof, under and in pursuance of the said act of this assembly, approved March third, eighteen hundred and eighty, the amount of the compensation of said special agent as agreed upon in his contract dated April twenty-eighth, eighteen hundred and eighty.

2. That the net balance of the recovery of said claim, left after the payment to any lawfully appointed agent of the State of Virginia now in charge of said claim of such commission as he is entitled to receive, shall be retained by said Mount Vernon Avenue Association and used by it for all the expenses incident to carrying out the objects and purposes of its charter, now granted, or as the said charter may hereafter be changed, modified, or amended by this assembly.

3. In consideration of the transfer of said claim hereby made, and upon its recovery, the avenue or road to be made by said association shall, upon its completion, be forever hereafter free from all charge of toll to the public, but under the control and supervision of said Mount Vernon Avenue Association.

4. This resolution shall be in force from its passage.

Approved March fifth, eighteen hundred and eighty-eight.

APPENDIX D D D.

SURVEY OF THE NORTHERN AND NORTHWESTERN LAKES.

D D D 1.

REPORT OF MAJOR JAMES B. QUINN, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

SURVEY AND LOCATION OF DANGER REEF NEAR MOUTH OF GOOSEBERRY RIVER, NORTH SHORE OF LAKE SUPERIOR.

This dangerous reef was located and plotted in October, 1889, and map forwarded to the Chief of Engineers with letter of November 5, 1889.

It lies about one-half mile from shore, is of small area, and has but 12½ feet of water over it at the shoalest place. There is deep water all around it, and it was not located on the charts or marked. It is a dangerous obstruction to vessels coasting the north shore of the lake or to those which may be befogged and out of their course.

There was allotted for this work the sum of $200, and the survey connected with its location cost $178.79, leaving a balance on hand of $21.21.

Respectfully submitted,

JAMES D. QUINN,
Major, Corps of Engineers.

D D D 2.

WATER-LEVEL OBSERVATIONS FOR LAKE ERIE.

REPORT OF MAJOR L. COOPER OVERMAN, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, July 9, 1890.

GENERAL: I have the honor to submit the following report on water-level observations for Lake Erie for the fiscal year ending June 30, 1890:

Tridaily observations were made at Erie and Cleveland, on Lake Erie; table herewith inclosed.

The elevation of the zero of the gauge at Cleveland above the plane of reference is 1.19 feet.

The elevation of the zero of the gauge at Erie above the plane of reference is 0.00 foot.

The elevation of the "check point" at Erie above plane of reference is 1.00 foot.

The accompanying table is a continuation of that given in the report of 1882, as published in Report of the Chief of Engineers, U. S. Army, for 1882, Part III.

I also transmit herewith a special report, in duplicate, on gauges and reference points pertaining to water-levels in this district.

Very respectfully, your obedient servant,

L. COOPER OVERMAN,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

Monthly mean water-levels for Cleveland and Erie harbors, expressed in feet below the plane of reference adopted in 1876.

Months.	Harbor at—		Months.	Harbor at-	
	Cleveland, Ohio.	Erie. Pa.		Cleveland, Ohio.	Erie, Pa.
1889.			1890.		
July	1.96	2.04	January	2.73	2.33
August	2.27	2.35	February	2.44	2.30
September	2.66	2.69	March	2.32	2.10
ctober	3.08	3.16	April	1.83	1.86
November	3.35	3.18	May	1.49	1.46
December	3.09	2.93	June	1.12	1.17

REPORT OF MR. WILLIAM T. BLUNT, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, June 30, 1890.

SIR: I have the honor to submit the following report on the recent reduction of gauges and reference points in this district to a common plane. For the most part it is copied from my original report presented March 20, 1889, but some additions have been made to bring it up to date.

During the winter of 1887 '88 I carefully examined all data which could be found in the office and compiled for future reference. It appeared that no systematic determination of the reference of any harbor was on file and that a great variety of datum planes have been in use in past years with few permanent references. It therefore became necessary to determine for each harbor some common plane for reduction of sounding, etc.

During my visits to the various harbors in July, 1888, a gauge was set at each as nearly as possible in the position used recently and each gauge was carefully referred to one or more permanent bench marks. The month of August was selected for comparison and proved to be unusually calm and favorable to good results, the extreme variation in water-level being 0.9 foot. A gauge observer was retained at each harbor, in most cases the light-house-keepers, and each gauge was read during the month three times each day, at 7 a. m., 1 p. m., and 7 p. m., and the results forwarded for reduction. In each case a check mark was placed immediately over the gauge, so that the observer could at any time determine if the gauge had been disturbed. The monthly mean reading at each harbor was compared with the standard reading at Cleveland (checked by that at Erie). These readings at Cleveland and Erie were taken below the plane of reference of Lake Erie, which is the high water of 1838 as determined and used by the United States Lake Survey, its reference to certain bench marks at Cleveland and Erie being given in the official report of the Lake Survey.

Since the regular observations of water-levels began in 1860, there have been great variations not only in the monthly means, but also in the yearly means, and the question of a standard water-level for the reduction of soundings, etc., becomes susceptible of various answers. The datum plane adopted by the lake survey for its pub-

lished charts since 1875 is the mean level of the lake from 1860 to 1875 inclusive, and is 2.34 feet below the plane of reference (high water of 1838). As this is the level at which soundings are given on sailing charts, it seems proper that it should be continued on the detail harbor work, and the reductions were therefore made on that basis. They were approved and adopted by you March 27, 1889.

The positions of zero of gauge and of all points of reference previously used in each harbor and admitting of comparison were determined with relation to this datum. The zeroes of old gauges were found to vary in level from .26 foot below to .64 foot above the datum. Throwing out these extremes which stand alone, the variation is from .18 to .42 foot above the datum. The mean level of the lake from 1860 to 1870 was used on a few minor lake-survey charts prior to 1875 and was 2 feet below the plane of reference or .34 foot above the datum. It is is therefore probable that the gauges were originally set at the mean level 1860–'70.

A note-book 8 by 5 inches with light leather cover, marked "Water-Levels and Bench Marks," is on file in the office, which contains detail results of the investigation with blank pages under the head of each harbor for entering any new information or references.

The following as of special interest and importance are selected for publication herewith.

GENERAL DATA.

		Above mean tide, New York.
Comstock Final Report, p. 609.	Mean surface, Lake Ontario, 1860–'75, inclusive	246.61
	Mean surface, Lake Erie, 1860–'75, inclusive	572.86
	Mean surface, Lakes Huron and Michigan, 1860–'75, inclusive	581.28
	Mean surface, Lake Superior, 1871–'75, inclusive	601.78
	Bench mark, coping of Ohio Canal, Cleveland	581.50
Comstock Final Report, p. 615.	B. M. × on water table, northeast corner Johnson House Block, southwest corner Front and East River streets, Cleveland	577.83
	B. M. × on stone water table, southwest corner brick block, northeast corner River and Superior streets, Cleveland	594.82
Comstock Final Report, p. 618.	B. M. 2 St. Mary's Canal	605.87
Chief of Engineers Report, 1876.	Lake Ontario, mean surface 1860–'75, below a B. M.	30.62
	Plane of reference	(2.43) 34.19
	Lake Erie, mean surface 1860–'75, below B. M. Ohio Canal	8.61
	Plane of reference, H. W. 1838	(2.31) 6.30
	Lakes Huron and Michigan, mean surface, 1860–'75, below a B. M.	11.39
	Plane of reference, H. W. 1838	(3.06) 8.33
	Lake Superior, plane of reference, below B. M. 2, 1.11, and therefore plane of reference above mean tide, New York	604.76
L. S. Chart, Lake Erie 1819. All Lake Survey Charts.	"During 1819 lake was at lowest known stage, during 1838 at highest. To reduce soundings given to lowest stage deduct 2 feet, to highest add 3½ feet." Therefore, low water of 1819 was 5½ feet below high water of 1838. State that mean surface from 1860 to 1875 was 4.94 feet below B. M., Johnson House Block.	
The preceding shows mean level 1860–'75 below B. M. Johnson House Block, according to		
	Comstock Final Report	4.97
	According to charts published before that report	(0.03) 4.94
Mean level 1860–'75, below B. M. Ohio Canal:		
	According to Comstock Final Report	8.64
	According to Chief of Engineers' Report, 1876	(0.3) 8.61

It is assumed that the figures from Final Report are correct, viz, 4.97 and 8.64.

The only reference found to high water of 1838 is in Chief of Engineers' Report 1876, which gives it as 6.30 below B. M. Ohio Canal. If this is assumed as correct, then mean level 1860–'75 below plane of reference (H. W. 1838) is 2.34.

We have, then, for adopted elevations above mean tide at New York:

Lake Ontario	Plane of reference	249.04±
	Mean surface, 1860–'75	246.61
Lakes Huron and Michigan.	Plane of reference, H. W. 1838	584.34±
	Mean surface, 1860–'75	581.28
Lake Superior	Plane of reference, probably H. W. 1838	604.76±
	Mean surface, 1871–'75	601.78
Lake Erie	Plane of reference, H. W. 1838	575.20
	Mean surface, 1860–'75	572.86
	B. M. coping Ohio Canal (destroyed), Cleveland	581.50
	B. M. Johnson House Block, Cleveland	577.83
	B. M. River and Superior streets, Cleveland	594.82
	Mean surface, 1860–'70	573.20±
	Low water, 1819	569.70±
	Or referred to our adopted datum plane (mean surface, 1860–'75).	
	Plane of reference, H. W. 1838	+2.34
	B. M. coping Ohio Canal (destroyed)	+8.64
	B. M. Johnson House Block	+4.97
	B. M. River and Superior streets	+21.96
	Mean surface, 1860–'70	+0.34±
	Low water, 1819	−3.16±

Following are the various points of reference determined up to the present time with relation to *mean level*, 1860–'75:

		Above mean tide, New York.
	MONROE.	
Top of water-sill	6 by 12 inches, west end of north pier. Usual low water as fixed by Colonel Cram, October 21, 1866 (map of November, 1867). It was apparently used on all succeeding work. It was used on Colonel Gillespie's chart, June, 1871, which also states that a B. M. is notched in willow tree and marked by brass tacks, but no description and no height given	+0.66
B. M. stone monument	Bolt in stone monument, on timbered mound a few feet north of inner end of north pier, 18.6 feet south from face of large elm	+8.66
	TOLEDO.	
B. M. Turtle Island	Bolt in stone monument, southeast of light-house and close to concrete wall; probably placed there for Colonel Blunt's survey, 1875, as that chart is the earliest where reference is found to this B. M. Captain Meade's chart, 1857, referred to mean level during survey 5° below sill., T. I. L. H. Colonel Gillespie's chart, 1871, to ordinary low water 5° below door sill, T. I. L. H. Colonel Blunt's chart, 1875, to general level of lake 5° below B. M. stone monument, T. I. Colonel Mechler's chart, 1877, to mean water level 5° below door sill, T. I. Tracing of Turtle Island, by D. E. Wright, under Colonel Blunt, September, 1876 (on file in Light-House engineer office), says: "B. M. head of spike 5.3 feet above low ordinary stage of Maumee Bay"	+5.35
B. M. crib	Top of old sheathing at southwest corner of main crib, and about 7 feet below deck of crib. This is reliable only after comparison with some permanent shore point	+3.33
B. M. U. S. lake survey.	Flat-head bolt in stone monument flush with ground at Manhattan, 315 feet northeast from △ Manhattan and about 100 feet from shore, close to fence, on open public land, just north of old canal bed. Lake Survey tracing, $\frac{1}{10000}$, shows this to be 13.63 above mean level, 1860–'75, based on readings during the occupation of camp. My own determination varies from this, but as it is based on numerous comparisons, it is adopted	+13.91
B. M. fire dock	Bolt in guard of fire dock at Manhattan. It is the third bolt-head from the northwest corner of cross dock, on west face of same. Crow-foot is cut at bolt and also on plank under	+7.90
B. M. △ Presqu'ile	Top of stone monument marking triangulation station at point of Presqu'ile, U. S. △ round hole cut in top	+10.11
B. M. △ Manhattan	Same at Manhattan on point of northerly side old canal; same mark on stone	+9.63
B. M. △ Grassy Point	Same at Grassy Point on the sand ridge; same mark on stone	+3.42
	PORT CLINTON.	
B. M. Light-house dwelling	Projecting course of foundation, northeast corner, about 6.35 feet below bottom of east window-sill. Major McFarland's plan, 1870, shows sketch of three plain courses. Soundings referred to "ordinary low stage" 3.66 below top of lowest course. Colonel Gillespie's chart, 1872, shows sketch same with second course cut away to leave lower course exposed. Soundings "reduced to low water 4.36 below B. M." Assistant Engineer Lawrence in October, 1872, used "5.61 below B. M." The foundation is probably 9 feet deep; one course, apparently the third from top, projects about 2 inches to the north and corresponds with descriptions above, but the upper course is the one cut away to expose second course. The projecting course as described above is the one used since 1887	+3.73
B. M. Lake House	The top of stone foundation, northeast corner Lake House, projects slightly beyond brick building and is about 2 feet above ground	+6.68
B. M. Opera House	Top of stone water table southeast corner brick opera house, corner Jefferson street and second street from lake	+9.52
B. M. Island House	Top of stone water table west side of main entrance at northeast corner Island House	+6.6
	SANDUSKY.	
B. M. Cedar Point L. H.	"B. M." cut on west end of lower step, north entrance to light-house. Lake survey tracing 1872, $\frac{1}{10000}$, says it is 17.72 above Colonel Gillespie's zero, and 5.76 above high water 1838. Careful levels and comparisons with standard guage at crib and with that at Ryan & Johnson dock results	+8.04
B. M. crib	Top of upper timber northeast side of boat-house, crow-foot cut	+5.14
B. M. Baltimore and Ohio machine shop.	Crow-foot cut on top of stone water table, 18 inches east of east door, close to corner pillar Baltimore and Ohio machine shop, corner Water Street and railroad	+9.31
B. M. Grotz building.	Crow-foot cut on stone foundation of iron corner pillar 8 inches from iron. Corner Hancock and Water Streets	+11.17
B. M. United States Express.	Crow-foot cut on outer corner of stone foundation of iron corner pillar, Wayne and Water streets	+12.41
B. M. United States post-office.	Top of lower water table at corner Market street and Columbus avenue about 3.2 feet above sidewalk	+22.96

		Above mean tide, New York.
HURON.		
B. M. L. H. foundation	X cut on top of northeast corner stone of foundation to iron light-house at end of west pier. It is about 1.2 feet above deck of pier.	+10.65
B. M. Shepherd Ho	X cut on northerly corner of 13 by 13 inch stone supporting iron pillar, southerly side of office doorway	+19.36
B. M. bridge foundation.	X cut on corner of large stone in rough pier of bridge. Not the highest point. It is 0.9 feet below bottom of girder	+6.91
VERMILLION.		
B. M. stone monument	Bolt in stone monument about 250 feet east of inner end of east pier, 88 feet westerly from 2½-foot basswood tree, 61 feet northerly from largest of three willows clustered near clump of willow, and 91 feet southerly from a United States sign-post. It is the only mark found here, probably set in Colonel Blunt's time, as his plan of 1875 is referred to "U. S. Standard Low Water," 4.66 lower than top of monument	+5.70
BLACK RIVER.		
B. M. light-house foundation.	X cut on southeast corner of stone foundation of old light-house, now gone. No mark was found there, but the pier has appearance of no change. The elevated walk to new light-house now passes over it. It is 325 feet inside of present light-house, and 530 feet outside of first decided angle in west pier. It is probably same as used by Colonel Raynolds in 1865	+9.84
B. M. door-sill W. W.	X cut on east end of east door-sill on north face of brick water-works building on beach west of river	+7.44
CLEVELAND.		
Zero of gauge	In 1881 the zero of gauge was established 2.8 feet below plane of reference, and has been so used till April 1, 1890, when it was changed to agree with others, and now is	−2.34
	Various spikes have been driven into the face of docks to mark plane of reference, but always carried away. The plane of reference is now established in the boat-house by three round-head steel nails, and also by height of Lake Shore and Michigan Southern Railroad draw.	
B. M. Johnson House Block.	X on foundation-stone at angle, corner Front and East River streets. (See Comstock Report.)	+4.97
B. M. River and Superior.	X on stone water-table southwest corner of brick block, northeast corner River and Superior streets. (See Comstock Report.)	+21.96
B. Ms. pike	Spike-head with crow-foot on raised walk south of boat-house 12.30 from southwest corner, and 17.51 from southeast corner	+3.81
Plane of reference	3 round-head steel nails, about one inch above floor of boat-house, in plank to which guage is nailed	+2.34
B. M. draw-bridge	Bottom of longitudinal iron-plate girders of new draw-bridge, Lake Shore and Michigan Southern Railroad	+6.72
FAIRPORT.		
B. M. light-house	X cut on top of stone foundation of stone light-tower on the hill east of river. Foundation is level with ground and projects about 18 inches outside of tower base. The B. M. is near southeast corner of largest capstone, nearly due east from lamp	+41.92
B. M. on tree	This is probably Colonel Raynolds's B. M. of 1865. It is a nail in crest of root trimmed off, on east side of largest poplar tree in a grove west of inner end of west pier. Tree is now 2 feet in diameter, and the only one of that size. It is 200 feet west from remains of old pier, 120 feet northeast from a double oak (the only oak near), and about 80 feet south from south line of new ice-house. Tree leans south, blazed on east face 3 feet from ground	+6.24
ASHTABULA.		
B. M. Lake Survey	Established in 1876. Now found in the middle of a road with its top broken off by ice in 1883. According to L. S. plans it was 3.14 above mean level. It is now	+2.63
B. M. brick building.	X cut on water-table, southwest corner of a brick building on Bridge street, 370 feet west from river. This building is 50 feet face, with one of 20 feet on east, and another new one on west, built in 1889	+11.13
B. M. hickory	Nail on root of large hickory on south side of bluff, 300 feet from Bridge street north and 500 feet from foot of bluff at point. On west side of river, half-way up bluff, and close to path	+28.32

CONNEAUT.	Above mean tide New York.
Here there was no August gauge, but heights depend on comparison with Erie for three consecutive quiet days in December, 1888.	
B. M. Gilbert's Bluff - Nail on root of a large tree standing alone near foot of Gilbert's Bluff, east of river, and nearly due west of old homestead. It was left by the railroad survey of 1888, and said by chief engineer to be correct. Tree was blazed and marked Elev. 9.530	+8.85
B. M. River Bluff .... Same mark found on root of a large tree on edge of small bluff at first bend below railroad bridge. Its height was determined by stadia and is approximate	+17.40±

There are many other minor references of use in hurried work without a level, but not of proper consequence for this paper. All information in relation to past records and recent work in this direction may be found with my sketches in the note-book mentioned, as also reasons for changes where made. In all harbors at the ordinary and convenient locations of gauge, marks will be found from sketches for quick setting of gauge.

Very respectfully,

WM. T. BLUNT,
Assistant Engineer.

Maj. L. COOPER OVERMAN,
Corps of Engineers, U. S. A.

DDD 3.

ISSUE OF PUBLISHED CHARTS OF THE NORTHERN AND NORTHWESTERN LAKES.

REPORT OF COLONEL O. M. POE, CORPS OF ENGINEERS, BVT. BRIG. GEN., U. S. A., FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 9, 1890.

SIR: I have the honor to transmit herewith, in duplicate, my annual report on the "issue of the published charts of the Northern and Northwestern Lakes" for the fiscal year ending June 30, 1890. * * *

Very respectfully, your obedient servant,

O. M. POE,
Colonel, Corps of Engineers,
Bvt. Brig. Gen., U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

ISSUE OF THE PUBLISHED CHARTS OF THE NORTHERN AND NORTHWESTERN LAKES.

The free issue of the charts to registered vessels was continued until February 20, 1890, when a communication was received containing a decision of the Judge-Advocate-General, dated February 12, 1890, interpreting section 226, Revised Statutes, as amended, and stating that the language of the law "does not admit of the free distribution of charts heretofore prevailing."

Since the receipt of this decision, nearly all charts have been sold at the uniform price of 30 cents each, this amount covering the expense of paper and printing paid by the Government. A few charts, however, have been issued free of charge for the official use of Government agents applying for them.

The following table shows the extent of this business:

Issue of the charts of the Northern and Northwestern Lakes during the fiscal year ending June 30, 1890.

Description.	Number.	Total.
On hand July 1, 1889	6,806	
Received during year	6,856	
		13,662
Issued to vessels, etc	3,278	
Sold at 30 cents each	4,182	
		7,460
On hand July 1, 1890		6,202

The sum of $1,254.60 was turned into the Treasury from sales of 4,182 charts at 30 cents each.

Total number of charts issued to July 1, 1889	167,249
Issued between July 1, 1889, and July 1, 1890	7,460
Total issued to July 1, 1890	174,709

Owing to changes in channels, the discovery of previously-unknown dangers, and the extension of works of river and harbor improvement, many of the charts now require additions and corrections in order to render them of the greatest service. In some cases limited surveys will be required to obtain the requisite data. Considering the extensive use made of the charts and their recognized value to the lake marine, the sum of $10,000 should be annually appropriated for the purpose indicated, and I respectfully repeat my recommendations of past years in this respect.

The cost of printing and issuing charts is now so small that it can not be further reduced.

I therefore have the honor to submit the following:

Estimate for the fiscal year ending June 30, 1892.

For printing and issuing charts for the use of navigators and electrotyping copper plates for chart printing	$3,000
For minor surveys and other expenses connected with correcting and extending the charts of the Northern and Northwestern Lakes	10,000
Total	13,000

Money statement.

Allotted from act approved March 2, 1889	$1,342.91
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,342.91
Amount that can be profitably expended in fiscal year ending June 30, 1890	13,000.00

APPENDIX E E E.

CONSTRUCTION AND IMPROVEMENT OF ROADS AND BRIDGES IN THE YELLOWSTONE NATIONAL PARK.

REPORT OF MAJOR WILLIAM A. JONES, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minn., July 7, 1890.

GENERAL: I have the honor to transmit herewith my annual report, in duplicate, upon the improvement and construction of roads and bridges in the Yellowstone National Park, for the fiscal year ending June 30, 1890.

Very respectfully, your obedient servant,

W. A. JONES,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

The project for this work was adopted in 1883, when the control was placed in the hands of officers of the Corps of Engineers, and consists in the construction and maintenance of about 225 miles of roads, with the necessary bridges, culverts, etc. The roads embraced in the project commence at Gardiner, at the north boundary line of the park; thence to Mammoth Hot Springs; thence to Upper Geyser Basin, passing through Norris Geyser and Lower Geyser basins; thence to the outlet of Yellowstone Lake via Shoshone Lake and the west arm of Yellowstone Lake, crossing the continental divide of the Rocky Mountains twice; thence to Yancey's via the Falls and Grand Cañon of the Yellowstone River; thence to Mammoth Hot Springs, completing the so-called belt road with a circuit of about 145 miles. In addition, there are projected: A road from the west boundary line of the park passing through Lower Geyser Basin and continued easterly to intersect the road along the Yellowstone River to the Falls; a road from Norris Geyser Basin to the Falls of the Yellowstone; a road from Yancey's to the east boundary line of the park; and a number of short branch roads and trails from the above-named roads to objects of interest off the main line of travel; in all, 225 miles of new roads, about 20 large and fifty small bridges, with many culverts, etc. Estimated cost, as revised in 1889 by my predecessor, $444,779.42.

At the beginning of the year the roads that were open to travel were:

Completed roads.—(1) The road from Gardiner to Mammoth Hot Springs, Norris, Lower and Upper Geyser basins, completed, except a

projected stretch of 10 miles of new road in Gibbon Cañon, designed to replace an equal length of the old road, and some minor changes in the location of different parts of the road. (2) The road from Norris Geyser Basin to the Falls of the Yellowstone.

Uncompleted roads.—(1) The road from Yellowstone Lake outlet to the falls. (2) The two roads known as the Madison Cañon road and Howard trail, from the western boundary line of the park to Lower Geyser Basin, where they join, and their continuation as one road to the uncompleted road from Yellowstone Lake outlet to the falls. (3) The road from Mammoth Hot Springs to Yancey's and its continuation to Clark's Fork mine.

The work during the past fiscal year was commenced July 1, 1889, and continued to September 24, when operations were suspended, except some small repair work, until April 15. There being no funds available as yet for continuing the work during the ensuing year, operations were brought to a close June 30, to await an appropriation by Congress.

The work accomplished during the year has been: (1) The construction of a part (1.1 miles) of the new road in Gibbon Cañon; a temporary connection was made with the old road at Cañon Creek, thus making the new part available for travel. The portion completed closely follows the river and in places was built in the stream. Two new pieces of road 1,600 feet and 6,700 feet in length were build around Brick-yard Hill and in the Swan Lake Basin respectively. The former obviates a bad hill and the latter avoids a soft piece of the old road. The above are all on the main line from Mammoth Hot Springs to the Geyser basins. (2) The road from Upper Geyser Basin to the outlet of Yellowstone Lake was commenced at both ends of the line by clearing off the timber and building bridges, except at the two crossings of the Firehole River. Grading was resorted to only where necessary. The parties working from the Upper Geyser Basin opened up in this way 3.5 miles along the Firehole River, while the parties at the other end opened up 7.4 miles of nearly level road along the lake shore and through heavy timber. It is estimated that $5,450 will complete the 10.9 miles opened up this year. (3) The road from Norris Geyser Basin to the Falls of the Yellowstone was continued 6,200 feet down the Grand Cañon to the new hotel site; of this distance, 2,225 feet were built on the precipitous side of the cañon, requiring a long retaining-wall. (4) The roads and trails in use were kept in repair.

The work was carried on by hired labor, and the purchase of materials and supplies after due advertisement and under sealed proposals. The hire of teams was made by advertisement and a formal written contract.

Summary of work done during the fiscal year.

New roads built	miles	3.85
New roads opened but not completed	do	10.90
New roads repaired and maintained	do	56.00
Old roads repaired and maintained	do	60.25
Bridges (trestles) built; two 90 feet long, two 30 feet long, seven 15 feet long, number		11
Bridges repaired	number	1

The total work done in the park by the engineers, commencing in 1883, is as follows:

New roads built	miles	62.85
New roads opened but not completed	do	10.90
Original wagon roads and trails repaired	do	63.50
Large and small bridges built	number	32

In addition, about 48 miles of old roads and trails were repaired, more or less. They have since been abandoned.

Amount expended during the fiscal year ending June 30, 1890, including outstanding liabilities	$50,000.00
Total amount expended upon the project since commencement of work in 1883 to June 30, 1890, including outstanding liabilities	184,779.42

GENERAL CONSIDERATIONS.

Roads are made for traffic. They are subject to a great deal of wear and tear. Waters wash away their surface; winds blow it away in dust; wheels and hoofs cut it up. The quantity of wear varies directly with the hardness of the surface. The harder it is, the less the cost of keeping it in repair. The annual cost of keeping a soft road in order will, when capitalized, be more than sufficient for making the surface hard. Soft roads are extravagant and wasteful except where the traffic is insignificant.

The project under which we are working calls for the construction of about 225 miles of road, at a total cost of $444,779.42. This is about $2,000 per mile, and does not include maintenance during construction. This is for constructing a road in rugged, mountainous country, densely timbered and swampy. It will involve some expensive feats in engineering. Evidently the estimate does not look beyond clearing the line of trees and brush and a moderate grading, making what is usually called a country road. The maintenance of such a road under the traffic which may reasonably be expected will be relatively expensive. It will be at the mercy of wind and water, and unless the surface be kept moist during the dry season the dust will be an intolerable nuisance. Such is the case over the portion now in use. The soil of the region is very light, and the summer atmosphere is exceedingly dry, with scarcely any precipitation of rain. I propose to organize a system of current repairs similar to that in use on railroads and to combine it with regular sprinkling over the lightest portions during the months of July, August, and September. It is proposed to carry forward the project to the point of making passable roads throughout the park at the earliest moment. When this shall have been accomplished it will be essential, from a business point of view, to proceed at once with covering the roads with a 6-inch layer of broken stone, well crowned, guttered, and drained, and thereafter to keep small repair parties continuously at work upon the general maintenance of the system.

The line of road proposed for construction is fully described in preceding reports. The magnitude of the proposition and the grandeur of the conception of the park may be better realized when we consider that its boundary is a rectangular figure with sides about 50 and 60 miles in length.

The appropriations for this work have so far been made under an "annual" appropriation, which has to be expended during the fiscal year for which it was made. In this class of appropriations all balances unexpended at the close of the fiscal year revert to the Treasury, so that, during the long sessions of Congress, on the 1st of July the work suddenly finds itself out of funds. Since the appropriation bills are usually passed some time in July or August, all hands have to be discharged right in the best part of the season. Everything has to be cleared up, carted a long distance and stored, and we have to trust to luck for assembling our experienced hands a month or so later when the new appropriation becomes available. Now, the working season

at such high altitudes is very short, from May to October at best, and the operation of cutting it in two in the middle is not wise. This matter can easily be remedied by adding to the appropriation section a proviso that the funds shall be available until wholly expended, whether within the fiscal year or not. Another proviso to the effect that the Secretary of War may carry on the work by contract or otherwise as may be most economical and advantageous to the Government would have the effect of placing it on exactly the same status as the appropriations for river and harbor improvements. The work being of the same character and being conducted under the same organization and methods, this work would be placed upon the same advantageous plane for economical administration as those.

It is proposed during the coming year to carry forward the project for opening new and maintaining completed roads with the utmost vigor. Owing to the remoteness of the locality and the absence of lines of supply it is difficult to maintain many parties along the line of new road, so that not more than $150,000 can be advantageously expended. With this it is expected to open at least 65 miles of new road and to maintain the completed roads in such condition as to make traveling reasonably comfortable and free from the dust nuisance.

In conclusion I wish to acknowledge the assistance rendered by Lieut. W. E. Craighill, Corps of Engineers, who has been in local charge of the work, and by Mr. E. Lamartine, overseer. Lieutenant Craighill's report, herewith, is referred to.

ABSTRACT OF ALLOTMENTS AND APPROPRIATIONS.

Allotments.

Under the appropriation of 1883	$23,570.03
Under the appropriation of 1884	23,000.02
Under the appropriation of 1885	23,209.37

Appropriations.

By act approved August 4, 1886	20,000.00
By act approved March 3, 1887	20,000.00
By act approved October 2, 1888	25,000.00
By act approved March 2, 1889	50,000.00
Total of allotments and appropriations	184,779.42

Money statement.

July 1, 1889, amount available		$50,000.00
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$45,174.87	
July 1, 1890, outstanding liabilities	4,825.13	
		50,000.00
Amount appropriated by act of August 30, 1890		75,000.00
Amount available for fiscal year ending June 30, 1891		75,000.00
Amount (estimated) required for completion of existing project		260,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		150,000.00

Abstract of proposals for team-hire opened July 6, 1889, by Maj. Charles J. Allen, Corps of Engineers.

[Horse or mule teams with drivers and equipment.]

No.	Name and address of bidder.	Teams.	Price per team per day of eight hours.
1	Peter Larsan, Helena, Mont	35	$4.49
2	Alex. Young, Mammoth Hot Springs, Wyo	35	*4.34
3	Paul McCormick, Junction City, Mont	35	4.89

*Accepted.

REPORT OF LIEUTENANT WILLIAM E. CRAIGHILL, CORPS OF ENGINEERS.

MAMMOTH HOT SPRINGS, WYO., *June* 30, 1890.

MAJOR: I have the honor to submit herewith my report on the construction and improvement of roads and bridges in the Yellowstone National Park during the fiscal year ending June 30, 1890.

Fifty thousand dollars was appropriated by the act approved March 2, 1889, and work was commenced on July 1.

The work has been done by day's labor, the necessary teams being furnished by contract under sealed proposals. The force employed during the summer of 1889, without material change, consisted of 1 overseer, 1 time-keeper, 4 foremen, 1 assistant foreman, 1 sawyer, 1 engine-driver, 2 blacksmiths, 5 cooks, 111 laborers, 1 water-carrier, 35 teams.

By the terms of the contract for the teams, the contractor supplied a driver for each two animals, and the necessary outfit of scrapers, chains, harness, and blacksmith tools. He also fed his animals. Laborers were hired by the day, and, with the drivers of the teams, were fed at the expense of the Government.

* * * * * * *

On the 28th of September the work of construction ceased for the season, and all laborers and teams were discharged except a small party for some necessary repairs to the road between Mammoth Hot Springs and Gardiner. These were kept until a few days into October when active operations were suspended. Work might have been continued for a week or two longer without serious inconvenience from the weather, but the money was beginning to run low and it was necessary to save some for repairs in the following spring.

During the winter the property stored at Mammoth Hot Springs was guarded, and a small amount of necessary work was done on the road between Gardiner and Mammoth Hot Springs by laborers hired for the occasion.

In the spring of 1890 operations were recommenced on the 15th of April, nearly a month later than the preceding season. At that date it was impossible to get farther into the Park than Mammoth Hot Springs, except on snow-shoes. The work of repairing the roads and getting them ready for the summer travel continued without interruption until the 27th of June. On the 30th of June the entire force employed was discharged on account of lack of funds, and the work completely suspended.

CONSTRUCTION WORK.

(1) *At the Grand Cañon of the Yellowstone.*—The work at this point consisted in completing the new road down the Cañon of the Yellowstone to give access for wagons to the new hotel there and to the points of interest below Cascade Creek.

The point at which work was carried on is about 32 miles from Mammoth Hot Springs and about 40 miles from the railroad. The total length of new road is 6,200 feet. The total cost per mile was $8,365.66. Two thousand two hundred and twenty-five feet were built on the precipitous side of the Cañon of the Yellowstone River, requiring a retaining-wall containing about 3,700 cubic yards of rock.

The material excavated on the sides of the Cañon consisted generally of a soft rock or hard clay interspersed with bowlders. It was difficult to handle, but since it has become compacted makes an excellent road-bed.

On the side hill the average width of the road is about 20 feet. Two bridges were included, both of which were described in the last Annual Report.

(2) *Between Yellowstone Lake Outlet and the Upper Geyser Basin.*—This is on the

route which when fully opened will give access to Shoshone Lake and the western end of Yellowstone Lake. The work was prosecuted at both ends of the line, *i. e.*, on the Yellowstone Lake and on the Firehole River above the Upper Geyser Basin.

Intermediate points being inaccessible to wagons, it was not economical to have working parties except at the two ends. As far as possible the work was confined to clearing the timber away and building bridges, and grading only where necessary. It is estimated that $500 per mile will be necessary to complete the part of the road constructed this year. On the Yellowstone Lake the road follows closely the shore of the lake and is almost level throughout.

The site was heavily timbered with a large proportion of spruce trees in the western end. This variety of tree caused greatest trouble, because of its luxuriant growth and because of the number of its roots extending in all directions just under the surface. Seven and four-tenths miles were opened. In this distance there were eleven trestle bridges built, two of which are 90 feet, two 30 feet, and seven 15 feet long. The total amount of material contained in them is about 150,000 feet, B. M.

On the Firehole River above the Upper Geyser Basin 3½ miles were opened. In this distance there are two crossings of the Firehole River. These will be made by trestles, the bill of material for which has nearly been sawed out. About 50,000 feet were sawed at this point, but nothing further was done toward building the bridges. The total length partly completed between the Yellowstone Lake and Upper Geyser Basin was 10.9 miles, at a total cost of $17,735.81, or at an average cost per mile of $1,627:14.

(3) *In the Gibbon Cañon.*—This road was projected to replace about 10 miles of the old road between Norris and the Lower Basin Hotel. It begins at a point in the Gibbon River about 2½ miles from the northern end of the cañon and about 27 miles from Mammoth Hot Springs. The new road as far as completed is close to the river's edge, and in places was built partly in the bed of the stream.

The project contemplates carrying the road to the hotel at the Lower Geyser Basin, but the end of the work was only brought to the mouth of Cañon Creek, where a temporary connection was made with the old road. The average cost per mile was $4,073.70. Considerable difficulties were encountered on account of numerous springs and swampy places, and for about half the distance the side-hill cutting was heavy.

(4) *Around the Brick-Yard Hill.*—The work at this point was a small piece, designed to replace one of the bad hills between Mammoth Hot Springs and Norris. The location is about 14 miles from Mammoth Hot Springs. The work was executed in June at a total cost of $672.14. The total length constructed was 1,600 feet, of which 1,100 feet were covered with timber. The work was done at a rate of $490.03 per mile for removing timber, and at a total expense of $2,218.06 per mile.

(5) *In Swan Lake Basin.*—About 5 miles south of Mammoth Hot Springs, near Swan Lake, for about 1¼ miles the road had never been graded. In the spring and fall at this point the mud was very deep, and at other times the road was rough. The new road obviates the difficulties at this point. When work ceased it was nearly complete, sufficiently so to allow vehicles to pass over it. Its length is 6,700 feet, and its cost $1,167.67, or at the rate of $920.93¾ per mile.

BRIDGES.

Eleven bridges were built during the year, all trestles. Two were 90 feet, two 30 feet, and seven 15 feet long. All were of a uniform pattern, the bents of 10 by 10-inch sawed timbers well braced; distance between bents 15 feet. The floor consists of two courses of 2-inch plank, the lower course laid diagonally across the stringers, which were seven in number and 8 by 10 inches in cross-section.

The design adopted for a truss-bridge for a 40-foot span (the longest yet found necessary) is shown on the accompanying drawing.*

It has been found necessary in building all the bridges, at once to have them of the simplest design and yet strong enough to carry heavy loads and be able, in the event of failure of appropriations, to go safely for a number of years without repairs. In the winter time they are probably subject to quite heavy loads of snow.

On May 27 experiments were made on the weight of snow from a drift in Kingman's Pass. Its weight was found to be 38¼ pounds per cubic foot. On a bridge in the same locality there was a few days before that date a drift of similar snow 4 feet 8 inches deep. Assuming that its average weight was 38¼ pounds per cubic foot, the load on the bridge was 178½ pounds on each square foot. But the most serious strains are felt in such portions of the bridges as railings and retaining walls where drifts accumulate when the snow settles. Many rails of 4 by 4 inch pieces supported at intervals of 14 feet were broken by this action. Taking the transverse strength of the wood at 500 pounds, the strain required to break a stick 4 by 4 inches with 14 feet between points of support, would be 979.6 pounds per square foot.

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* Omitted.

GENERAL REPAIRS.

During the summer a small repair party consisting of one assistant foreman, three laborers, and one team was maintained. This party moved from place to place as was found necessary.

By the end of the fiscal year the wagon roads had been thoroughly repaired throughout the entire length traveled, at a total cost of $7,500.10.

The road through the Gardiner Cañon is most difficult to maintain. It passes under a mountain side down which large rocks frequently roll, especially during storms, making the road extremely dangerous. The location at this point should be changed. The cost of repairs would, I think, be reduced by having a larger number of men engaged on that work throughout the summer. They should be divided into several independent parties, each in charge of a certain section of road, upon which it would be constantly engaged.

The lumber used was sawed by the portable mill purchased at the beginning of the season of 1889. Its performance has been very satisfactory. It has moved without serious accident or difficulty from place to place so as to be near as possible to the site of the bridge in process of construction. The cost of manufacture has been about $5 per 1,000 feet, B. M.

RECONNAISSANCE IN THE SOUTHERN PART OF THE YELLOWSTONE NATIONAL PARK, AUGUST, 18-9.

Under instructions from Maj. Charles J. Allen, Corps of Engineers, I made a reconnaissance in the month of August of the region about the southern portion of the park.

* * * * * *

The only instruments carried on the trip were an aneroid barometer with its attached thermometer and a pocket compass. Elevations given in this report are therefore approximate only, and distances are estimated.

After examining the country passed over, I am convinced that if the Union Pacific Railway wishes to make an entry into the park from the southern side, unless there is some very serious obstacle outside, they should make their point of entry where the Snake River crosses the southern line.

A good wagon road could then be easily built from this point to the outlet of Shoshone Lake, connecting at that point with the belt road now in course of construction. This road would be a good one to travel over when completed because it would have no bad hills and it would be inexpensive to build. Lewis Lake would afford a good location for a hotel, which would be only 12 miles from the railroad, and about a half a day's drive from each of the proposed hotels at the west end of the Yellowstone Lake and of Shoshone Lake. If the point of entry is selected in Falls River Basin instead of on Snake River the conditions are all unfavorable for the wagon road to the points of interest in the park. The nearest point with which connection could be made is the west end of Shoshone Lake, distant from Fall River Basin about 20 miles, but between the two is the Continental Divide, rising to a height of 8,500 feet, or 2,000 feet above Falls River Basin, and about 750 feet above Shoshone Lake. The country through which the road would pass is extremely rugged and difficult, and the road would be expensive to build and disagreeable to travel over on account of the long and probably steep hills it would have. It would also be one of the last to be clear of snow in the sping. The last is one of the strongest arguments in favor of Madison Cañon route as against any point on the southern line. An interesting report on this subject, by Mr. R. Hering, is to be found in "The Sixth Annual Report of the U. S. Geological Survey of the Territories, embracing portions of Montana, Idaho, Wyoming, and Utah, being a report of progress of the explorations for the year 1872, by F. V. Hayden, United States geologist."

The number of tourists who come with camping outfits from the south is sufficient to warrant the expenditure of the small sum that would be necessary to keep clear the trail they travel over. They follow Sheridan's trail to Shoshone Lake, thence by the trail to Upper Geyser Basin, then on the wagon roads through the park, returning to the outlet of Yellowstone Lake, and from there to Shoshone Lake again, and then over Sheridan's trail to the southern boundary.

During the summer a small repair party went over all of the pack trails included in this route except that south of Lewis Lake. In this unimproved part of the route there are in all about 5 miles, the scenes of former forest fires, very much obstructed by fallen timber. As early as practicable next season this ought to be cleared away. The expense would probably not exceed $200.

Respectfully submitted.

WM. E. CRAIGHILL,
First Lieutenant, Corps of Engineers, U. S. Army.

Maj. WILLIAM A. JONES,
Corps of Engineers, U. S. A.

APPENDIX F F F.

F F F 1.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE COLUMBIA.

REPORT OF MAJOR GARRETT J. LYDECKER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF THE COLUMBIA,
Vancouver Barracks, Wash., July 1, 1890.

SIR: I have the honor to submit the following report as chief engineer, Department of the Columbia, for the fiscal year ending June 30, 1890.

This office was in charge of Lieut. L. A. Lovering, Fourth United States Infantry, until August 14, 1889, when, by General Orders No. 12, series of 1889, Headquarters Department of the Columbia, he was relieved and I was assigned to such charge, pursuant to paragraph 16, Special Orders No. 149, Adjutant-General's Office, Headquarters of the Army, June 28, 1889.

Field operations during the year comprised: (1) Resurvey of the boundaries of the Fort Walla Walla military reservation and the establishment of permanent stone monuments marking the corners thereof. (2) A survey of the sewerage and water systems of the same post. (3) A personal examination of the Spokane River, from the outlet of Lake Cœur d'Alêne to Post Falls, with a view to ascertaining whether the completion of certain dams at the latter point would subject the military reservation of Fort Sherman to overflow. (4) Personal examination of the military reservation of Gig Harbor, with reference to trespass thereon. (5) Surveys relating to sewage disposal and irrigation of post gardens at Vancouver Barracks. (6) Surveys and markings of roads and fences on the military reservation at Vancouver Barracks. (7) Survey of the St. James Mission claim within the limits of that reservation.

Office work included the preparation of maps and reports based on the surveys and examinations referred to above; the addition to the

progress sheets of the department map of all new information as received from time to time; additions to the new map of Alaska; various reports in relation to matters referred to this office for information and action, and miscellaneous work as follows:

Maps and plans drawn	14
Tracings made	23
Solar prints	91
Negatives for official use	22
Maps mounted on linen	21
Reports of scouts received and recorded	9

The instrumental work in the field, clerical, draughting, and photographic work in the office, have all been executed with marked fidelity and efficiency by General Service Clerk Charles A. Homan. Besides him there has been no office force, nor have there been any funds available for use in this office during the year. Stationery and such other materials as were imperatively necessary for carrying on the operations of the office were, as usual, supplied by the Quartermaster's Department.

Very respectfully, your obedient servant,

G. J. LYDECKER,
Major of Engineers, U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

FFF 2.

EXPLORATIONS AND SURVEYS IN THE DIVISION OF THE MISSOURI.

REPORT OF CAPTAIN WILLIAM L. MARSHALL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

HEADQUARTERS DIVISION OF THE MISSOURI,
ENGINEER OFFICE,
Chicago, Ill., July 5, 1890.

GENERAL: I have the honor to submit my annual report as engineer officer, Division of the Missouri, for the fiscal year ending June 30, 1890.

The office force has consisted of one general service clerk, Frederick A. Peterson.

There has been no field work in progress during the year.

The office work has consisted in collecting, compiling, and plotting geographical information for the improvement of existing maps; in making reductions and enlargements and fac-simile copies and tracings of maps of military and Indian reservations, posts, scouts, reconnaissances, etc., for use at these headquarters and elsewhere in the division for file and forwarding.

During the year monthly reports of operations have been received from the engineer officers of the departments included in this division. Besides these reports these officers are required to forward such special reports and maps of work done as may be useful to the major-general commanding the division.

A tabular statement is appended, showing the number of maps re-

ceived and issued; also list of maps and tracings drawn, and miscellaneous matter:

TABULAR STATEMENT OF MAPS RECEIVED AND ISSUED.

Title of maps.	On hand June 30, 1889.	Received during 1889–'90.	Issued.
United States, showing military posts, departments, divisions, etc	6	.....	1
Yellowstone and Missouri rivers	30	.....	2
New Mexico and Arizona	28	.....	1
United States and Territories, General Land Office, 1886	2	.....	1
That portion of the Department of the Platte and adjacent territory west of the one hundred and third meridian	.....	20	2
Total	66	20	7

LIST OF PLANS AND MAPS DRAWN.

Plan of a proposed range-house for the small-arms range at Fort Sheridan, Ill.

Plan of a proposed visitors' stand at the small-arms range at Fort Sheridan, Ill.

Plan of the small-arms range at Fort Sheridan, Ill., with details of "target and telephone house," "revetment wall and trench."

Tracing of map of the country draining into Red Butte Creek, with regard to the water supply of Fort Douglas, Utah.

Two copies of a map showing Generals Crook and Terry's routes of march during 1876 against the hostile Indians in Dakota and Montana.

Sundry sketches of details of rifles, etc., for target practice.

Plans for a book-case, a medicine chest, an instrument case, a case for office files, etc.

Made sketches of sundry objects and blue-prints of same.

Respectfully submitted.

W. L. MARSHALL,
Captain of Engineers,
Engr. Officer, Div. Mo.

Brig. Gen. THOMAS LINCOLN CASEY,
Chief of Engineers, U. S. A.

F F F 3.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE PLATTE.

REPORT OF LIEUTENANT CHARLES A. WORDEN, SEVENTH INFANTRY, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF THE PLATTE,
Omaha, Nebr., June 30, 1890.

GENERAL: I have the honor to submit the following report of operations of the engineer office, Headquarters Department of the Platte, for the fiscal year commencing July 1, 1889, and ending June 30, 1890.

I was appointed acting engineer officer of this department, as an-

nounced in General Orders No. 13, Headquarters Department of the Platte, dated August 21, 1889, then relieving First Lieut. C. M. Truitt, A. D. C., from the charge of this office.

In compliance with paragraph 4, Special Orders No. 117, Headquarters Department of the Platte, on the 14th of December, 1889, I went to Fort Douglas, Utah, as one of a board of officers ordered to convene at that post to report as to the most practicable and effective means to be employed to correct the defects in the water and sewerage systems at that post. From this duty I returned to my station (Omaha, Nebr.,) December 25, 1889, and shortly after I submitted a report of my investigation, accompanied by a map showing the proposed improvements in the water and sewer systems of Fort Douglas, Utah.

The following is a list of the office work performed during the year:

Plan of Fort Omaha, Nebr., on a scale of 100 feet to an inch, corrected up to August 1, 1889.

Map showing the Fort Washakie military reservation and the location of 160 acres of land requested for school and mission purposes by the Protestant Episcopal Church in the vicinity of the post of Fort Washakie, Wyo.

Plan of Camp George Crook, Nebr., commanded by Brig. Gen. John R. Brooke, from August 20 to September 20, 1889.

Plat showing collectively all the military posts and reservations in the department of the Platte, corrected up to January 10, 1890.

Plan (as above mentioned) of the proposed improvements in the water and sewerage systems of Fort Douglas, Utah.

Map of a portion of the Department of the Platte, showing concentration of troops at Camp George Crook, Nebr., for field maneuvers of 1889.

Map of military reservation of Fort Washakie, Wyo., and proposed addition so as to include the hot springs within a few miles of the post of Fort Washakie.

Plans of all the target ranges in the Department of the Platte, prepared from the original sketches and notes of officers at the various posts, as requested by Major D. W. Benham, inspector of small arms practice of this department.

Plat to show proposed routes of the Burlington and Missouri River and Missouri Pacific railroads over the new United States military reservation near Bellevue, Nebr.

Map showing the location of the Bellevue target-range and other points of military importance in the vicinity.

Map of the exploration of the Green River from the mouth of Ashley Creek to Blake City, Utah, from notes and sketches by Capt. Thomas E. Rose, Sixteenth Infantry.

Map of a reconnaissance from Fort McKinney, Wyo., to Fort Hall, Idaho, *via* the Lower Geyser Basin, Yellowstone National Park, made by Capt. W. S. Stanton, Corps of Engineers, and First Lieut. E. Z. Stiver, Third Cavalry, in 1881.

Nearly one hundred copies of the "Map of that portion of the Department of the Platte and adjacent territory west of the 103d meridian," prepared in this office in 1889, have been issued to officers in this and other military departments on request; also to the various postmasters, county surveyors, county clerks, and others who furnished data used in its compilation and who were promised one or more copies of the map in return for their information. About twenty copies of this map have been mounted on muslin and supplied to the officers at these headquarters and posts in this Department.

Blue-print reproductions (from tracings) have been made of many of the aforementioned maps, plats, etc., some of which have been mounted on cloth and placed in the offices at these headquarters for reference.

The unserviceable odometers and prismatic compasses at the various posts in this department have been replaced by similar instruments in good condition, which were furnished by the commanding officer of Willets Point engineer depot, in compliance with a request sent through your office.

Very respectfully, your obedient servant,

CHAS. A. WORDEN,
First Lieut. Seventh Infantry,
Acting engineer officer, Department of the Platte.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

F F F 4.

EXPLORATIONS AND SURVEYS IN THE DIVISION OF THE PACIFIC.

REPORT OF LIEUTENANT JAMES E. RUNCIE, FIRST ARTILLERY, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

ENGINEER OFFICE,
HEADQUARTERS DIVISION OF THE PACIFIC,
DEPARTMENT OF CALIFORNIA,
San Francisco, Cal., July 1, 1890.

SIR: I have the honor to submit my report of operations for the fiscal year ending June 30, 1890.

Since rendering my report for the last fiscal year (1889) I have been on duty at these headquarters as acting engineer officer, under authority of the Secretary of War and by virtue of General Order No. 2, headquarters Division of the Pacific, March 3, 1888.

Assistant C. Winstanley has been continually on duty in this office as topographer and draughtsman.

The work of the office has consisted of the following:

REPORTS.

On the title of the United States to the military reservations on Puget Sound and the defenses to the entrance to Admiralty Inlet.

On the title of the United States to Peninsular Island, in the bay of San Francisco.

SURVEYS.

Surveyed and laid out known-distance and skirmish ranges for the Division (of the Pacific) rifle competition at Santa Cruz, Cal.

Surveyed Lombard street as proposed to be graded between Presidio and Fort Mason.

Surveyed additions to and alterations in roads and buildings at Fort Mason, Cal.

ORIGINAL DRAWINGS.

Made design and specification for map-case and draughting-table for division inspector of artillery.

Profile of ground along the southern boundary of the Presidio reservation.

Map showing number of houses on city blocks bounded by Central avenue, Washington and Spruce streets, and the Presidio reservation, which it was proposed to sewer across said reservation.

Compiled map of Admiralty Inlet, showing possibilities of defense.

Platted profile of Lombard street as proposed to be graded between the Presidio and Fort Mason.

Platted profile of road along part of the southern boundary of the Presidio.

Made colored diagram of the flags of all nations for the division commander.

Compiled chart and profile of bottom, over the old line of submarine cable from Fort Mason to Alcatraz Island and the proposed new line between the Presidio and Alcatraz.

Prepared plans and estimates for two gymnasia for military posts.

Made profile showing proposed approaches to Fort Mason from Polk street.

Made drawings for double bake-oven for the Presidio.

Sketch of proposed gymnasium and swimming tank for the Presidio of San Francisco, Cal.

New map of Fort Mason from data in the office.

Map of water supply and drainage at Fort Mason.

Drawings of modified V-flume for water supply at Fort Apache, Ariz., as proposed by Capt. J. W. MacMurray, First Artillery.

Enlarged map of the Big Horn and Little Big Horn rivers and the adjacent country for Captain Woodruff, acting commissary of subsistence.

Map of the northern portion of the city of San Francisco, showing the "Peter Smith" claim.

TRACINGS.

Map of scout made by Captain Kerr, Sixth Cavalry, from Fort Wingate, N. Mex.

Scout of detachments Troops A, C, H, and K, Sixth Cavalry, from Fort Wingate, N. Mex., to Fort Apache, Ariz., and return, under the command of Capt. W. M. Wallace, Sixth Cavalry.

Charts of Whidby Island and Deception Pass, of Puget Sound, and of the mouth of the Columbia River.

Drawings of 16, 12, 10, and 8 inch guns, and the 12-inch rifled mortar for the division inspector of artillery.

Design for proposed medal for artillery target practice (Lieutenant Harris, First Artillery).

Maps of Presidio reservation, showing roads leading to the national cemetery; showing the extent and location of three military reservations in the vicinity of Big Harbor, Wash.; showing number of houses on city blocks adjoining the Presidio, proposed to be sewered through the reservation; of the entrance to Admiralty Inlet, showing possibilities of defense; of the southern boundary of the Presidio reservation, showing land claimed by the city of San Francisco.

Profile of road on southern boundary of Presidio.

Maps of townships 30 and 31 north, range 8 west, Willamette meridian, for division commander; and of Admiralty Inlet and Deception Pass.

Chart and profile of bottom, showing the old line of submarine

cable from Fort Mason to Fort Alcatraz and the proposed new line from the Presidio to the same.

Drawings of proposed gymnasium for military post.

Map of the northern part of the city of San Francisco, showing opened streets communicating with Fort Mason and the Presidio.

Drawings of double bake-oven for the Presidio of San Francisco.

Plan of Fort McDowell, Ariz.

Maps of proposed military reservation at San Diego, Cal.; cf Fort Mason, Cal.; showing water supply and drainage of Fort Mason, Cal.; of the northern portion of the city of San Francisco, showing the "Peter Smith" claim.

Drawings of modified V-flume for the water supply of Fort Apache, Ariz.

BLUE PRINTS.

Proposed defenses of San Francisco Bay and of Half-Moon Bay; map of march of Light Battery K, First Artillery, to Monterey and return, in 1886; road on Presidio reservation as proposed by Lieut. Col. R. N. Batchelder, deputy quartermaster-general; chart of Whidby Island and Deception Pass; of Puget Sound; of mouth of the Columbia River; drawings of 16, 12, 10, and 8 inch guns and 12-inch rifled mortar for division inspector of artillery; map of entrance to Admiralty Inlet; profile of Lombard street between Presidio and Fort Mason; map of southern boundary and of eastern boundary of the Presidio reservation; profile of road on southern boundary of Presidio; maps of Admiralty Inlet and Deception Pass, and of townships 30 and 31 north, range 8 west, Willamette meridian; chart of San Francisco Bay; chart and profile of submarine cable lines; map of northern portion of the city of San Francisco, and of land at Port Angeles, Wash.; plottings of gun and mortar firing for division inspector of artillery, 63 sheets; maps of portion of Los Angeles County, of Fort Mason, of water supply and drainage, Fort Mason, Cal.; of the Presidio reservation, prepared and traced by Lieutenant Todd, First Artillery, 274 sheets.

MAP MOUNTINGS.

Two maps of United States railroads, 8 sheets; map of Department of California for division commander; map of the United States for depot quartermaster, 4 sheets; mounted and colored map of Department of the Columbia for the assistant adjutant-general, Division of the Pacific; map for the division inspector of artillery.

Very respectfully, your obedient servant,

J. E. RUNCIE,
First Lieut., First Artillery, Acting Engineer Officer.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

LAWS

AFFECTING

THE CORPS OF ENGINEERS,

UNITED STATES ARMY,

FIFTY-FIRST CONGRESS, FIRST SESSION.

1889-'90.

3607

LAWS

AFFECTING

THE CORPS OF ENGINEERS, UNITED STATES ARMY.

FIFTY-FIRST CONGRESS, FIRST SESSION, 1889–'90.

ACTS.

AN ACT to authorize the construction of a bridge across the Missouri River at some accessible point within one mile north and one mile south and east of the mouth of the Kansas River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Missouri River and Land Improvement and Construction Company, a corporation organized under the laws of the State of Kansas, or its assigns, is hereby authorized to construct and maintain a bridge across the Missouri River at such a point as may be hereafter selected by said corporation, or its assigns, within one mile north of the mouth of the Kansas River, in the county of Wyandotte, in the State of Kansas, and one mile south and east of the mouth of the Kansas River, in the county of Wyandotte, in the State of Kansas, and in the county of Jackson, in the State of Missouri, to the county of Clay, in the State of Missouri, as shall best promote the public convenience and welfare and the necessities of business and commerce; and also to construct accessory work to secure the best practicable channel-way for navigation and confine the flow of the water to a permanent channel at such point; and also to lay on and over said bridge a railway track or tracks for the more perfect connection of any railroads that are or shall be constructed to said Missouri River at or opposite said point; and said corporation may construct and maintain ways for wagons, carriages, horses, or other animals, and for foot-passengers, charging and receiving reasonable toll therefor as may be approved from time to time by the Secretary of War.

SEC. 2. That said bridge shall be constructed and built without interference with the security and convenience of navigation of said Missouri River beyond what is necessary to carry into effect the rights and privileges hereby granted; and in order to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the Missouri River, the shore-lines at high and low water, the direction and strength of the currents at all stages, and the soundings accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built: *Provided*, That if said bridge be built above the mouth of the Kansas River it shall be built as a high bridge with unbroken and continuous spans, having at least one channel span of not less than four hundred feet clear channel-way, all other spans over the water-way to have a clear channel-way of not less than three hundred feet; and all said spans shall have a clear head-room of not less than fifty feet above high-water mark; and if it shall be built below the mouth of the Kansas River it shall be built as a high bridge with unbroken and continuous spans, all spans over the water-way to have a clear channel-way of not less than four hundred feet, and a clear head-room of not less than fifty-five feet above high-water mark. And the piers of said bridge shall be paralleled with the current of said river at the stage of water which is most important to navigation, and the bridge itself shall be built as nearly as may be at right angles thereto; and said company or corporation shall maintain, at is own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe: *Provided, also,*

That all railway companies desiring to use said bridge shall have and be entitled to equal rights and privileges in the passage of the same, and in the use of the machinery and fixtures thereof, and of all the approaches thereto, under and upon such terms and conditions as shall be prescribed by the Secretary of War, upon hearing the allegations and proofs of the parties, in case they shall not agree.

SEC. 3. That the Secretary of War is hereby authorized and directed, upon receiving such plan and map and other information, and upon being satisfied that a bridge built on such plan, and with such accessory works, and at such locality, will conform to the prescribed conditions of this act, to notify the company that he approves the same; and upon receiving such notification the said company may proceed to an erection of said bridge, conforming strictly to the approved plan and location; and should any change be made in the plan of the bridge or said accessory works, during the progress of work thereon, such change shall be subject likewise to the approval of the Secretary of War, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said Missouri River, caused or alleged to be caused by said bridge, the case may be brought in the circuit court of the United States of the State of Kansas or State of Missouri in which any portion of said obstruction or bridge may be located.

SEC. 4. That the said bridge and accessory works, when built and constructed under this act and according to the terms and limitations thereof, shall be lawful structures; and said bridge shall be recognized and known as a post-route upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge; and said bridge shall enjoy the rights and privileges of other post-routes in the United States; and Congress reserves the right at any time to regulate by appropriate legislation the charges for freight and passengers over said bridge.

SEC. 5. That the United States shall have the right of way for such postal-telegraph lines across said bridge as the Government may construct or control.

SEC. 6. That Congress shall have power at any time to cause to be removed all material and substantial obstructions to the navigation of said river by the construction of said bridge and its accessory works; and the expense of altering said bridge or removing such obstructions shall be at the expense of the owners of or persons controlling such bridge.

SEC. 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date hereof.

SEC. 8. Congress shall have power, at any time, to amend or repeal this act as in its judgment the public interests shall require.

Approved, February 6, 1890.

AN ACT to authorize the construction and maintenance of a bridge across the Missouri River at a point to be selected in the county of Douglas, or in the county of Sarpy, in the State of Nebraska, and the county of Pottawattamie, in the State of Iowa, and to make the same a post-route.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Iowa and Nebraska Western Railway Company, a corporation organized under the laws of the State of Iowa, is hereby authorized to construct and maintain a bridge across the Missouri River on the line on which its railway may be hereafter located, either in Douglas or Sarpy Counties, in the State of Nebraska, and the county of Pottawattamie, in the State of Iowa, and also to construct accessory works to secure a practicable channel way for navigation, and confine the flow of the water to a permanent channel at such point; and also to lay on and over such bridge a single or double railway track, for the more perfect connection of its railway, when constructed to said river: *Provided*, That said bridge shall not be located within one-third of a mile of any existing bridge.

SEC. 2. That said bridge shall be constructed and built without material interference with the security and convenience of the navigation of said river beyond what is necessary to carry into effect the rights and privileges hereby granted; and in order to secure that object the said company or corporation shall submit to the Secretary of War for his examination and approval a plan, design, and drawings of the bridge, and a map of the location, giving for the space of one mile above and one mile below the proposed location the topography of the banks of the river, the shore-lines at high and low water, the direction and velocity of the current at the time the aforesaid plan is constructed, and the surroundings, accurately showing the bed of the stream, the location of any other bridge or bridges across the said river within the limits mentioned, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the

Secretary of War the bridge shall not be built: *Provided*, That the said bridge shall be built with unbroken and continuous spans, it shall have three or more channel spans of not less than three hundred feet each in the clear, and shall not be of less elevation in any case than fifty feet above extreme high-water mark, as understood at the point of location, to the bottom chord or to the lowest member of the floor system of the spans of the bridge, and the piers of said bridge shall be parallel to the current of said river, and the main span shall be over the main channel of the river and not less than three hundred feet in length in the clear; and said company or corporation shall maintain, at its own expense, from sunset till sunrise, such lights or other signals on such bridge as the Light-House Board shall prescribe.

SEC. 3. That the Secretary of War is authorized and directed, upon receiving such plan, map, and other information, and upon being satisfied that the bridge built upon such plan and with such accessory works and at such locality will conform to the prescribed conditions of this act, to notify said company or corporation that he approves the same; and upon receiving such notification said company or corporation may proceed to the erection of said bridge, conforming to the approved plan and location; and should any change be made in the plan of the bridge or said accessory works, either during the progress of the work thereon or after it shall be completed, such change shall be subject likewise to the approval of the Secretary of War; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river caused or alleged to be caused by said bridge, the case may be brought in the circuit court of the United States of the district where said bridge or any part thereof is located.

SEC. 4. That the said bridge and accessory works, when built and constructed under this act and according to the terms and limitations thereof, shall be lawful structures, and shall be recognized and known as a post-route having the rights and privileges accorded to other post-routes; that no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroads or public highways leading thereto, and that the United States shall have the right of way across said bridge for postal-telegraph lines.

SEC. 5. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

SEC. 6. That Congress shall have power at any time to cause to be removed all material and substantial obstructions to the navigation of said river by the construction of said bridge and its accessory works, and the expense of altering said bridge or removing such obstructions shall be borne by the owners of or persons controlling the same.

SEC. 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date hereof.

SEC. 8. Congress shall have power, at all times, to amend or repeal this act as in its judgment the public interests shall require.

Approved, February 21, 1890.

AN ACT to amend and alter an act entitled "An act to authorize the construction of a railroad, wagon, and foot-passenger bridge across the Mississippi River at or near Burlington, Iowa," approved August sixth, eighteen hundred and eighty-eight.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for commencement and completion of the bridge authorized by said act, as provided in section six thereof, be, and is hereby, each extended two years from the passage of this act.

SEC. 2. That the said Burlington and Illinois Bridge Company, its successors and assigns, be, and are hereby, authorized to construct and maintain, under the provisions of said act, as far as applicable, except as herein modified, altered, or amended, either a railroad, wagon, and foot-passenger bridge, or a railroad, or wagon and foot-passenger bridge, and in the event that only a wagon and foot-passenger bridge be built that the provisions in said act for the passage of railroad trains and rights of railway companies incident thereto shall not apply.

SEC. 3. That in case the bridge authorized at or near Burlington, Iowa, by an act approved August sixth, eighteen hundred and eighty-eight, be constructed in the immediate vicinity of the existing railroad bridge, the length of spans required by said act

may be so modified as to make the clear channel-ways correspond in length and location to the clear channel-ways of the existing bridge: *Provided*, That in the opinion of the Secretary of War the interests of navigation be not materially affected thereby.

Approved, February 21, 1890.

AN ACT to amend and alter an act entitled "An act to authorize the construction of a railroad, wagon, and foot-passenger bridge across the Mississippi River at or near Clinton, Iowa," approved July sixteenth, eighteen hundred and eighty-eight.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for commencement and completion of the bridge authorized by said act, as provided in section six thereof, be, and are hereby, each extended two years from the passage of this act.

SEC. 2. That the said Clinton and Illinois Bridge Company, its successors and assigns, be, and are hereby, authorized to construct and maintain, under the provisions of said act, as far as applicable, except as herein modified, altered, or amended, either a railroad, wagon, and foot-passenger bridge, or a railroad or wagon and foot-passenger bridge, and in the event that only a wagon and foot-passenger bridge be built, that the provisions in said act for the passage of railroad trains and rights of railway companies incident thereto shall not apply.

SEC. 3. That in case the bridge authorized at or near Clinton, Iowa, by an act approved July sixteenth, eighteen hundred and eighty-eight, be constructed in the immediate vicinity of the existing railroad bridge, the length of spans required by said act may be so modified as to make the clear channel ways correspond in length and location to the clear channel-ways of the existing bridge: Provided, That in the opinion of the Secretary of War the interests of navigation be not materially affected thereby.

Approved, March 1, 1890.

AN ACT to increase the pensions of certain soldiers and sailors who are totally helpless from injuries received or diseases contracted while in the service of the United States.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That all soldiers, sailors, and marines who have since the sixteenth day of June, eighteen hundred and eighty, or who may hereafter become so totally and permanently helpless from injuries received or disease contracted in the service and line of duty as to require the regular personal aid and attendance of another person, or who, if otherwise entitled, were excluded from the provisions of "An act to increase pensions of certain pensioned soldiers and sailors who are utterly helpless from injuries received or disease contracted while in the United States service," approved June sixteenth, eighteen hundred and eighty, shall be entitled to receive a pension at the rate of seventy-two dollars per month from the date of the passage of this act or of the certificate of the examining surgeon or board of surgeons showing such degree of disability made subsequent to the passage of this act.

Approved, March 4, 1890.

AN ACT to amend an act entitled "An act to authorize the construction of a wagon and foot-passenger bridge across the Mississippi River at or near Lyons, Iowa."

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That an act entitled "An act to authorize the construction of a wagon and foot-passenger bridge across the Mississippi River at or near Lyons, Iowa," approved March second, eighteen hundred and eighty-nine, be, and the same is hereby, amended as follows, namely:

Strike out the title of said act and insert in lieu thereof the following:

"An act to authorize the construction of a railroad or wagon and foot-passenger bridge across the Mississippi River at or near Lyons, Iowa."

Strike out the first section of said act and insert in lieu thereof the following:

"That the Lyons and Fulton Bridge Company, a corporation organized and existing under and by virtue of the laws of the State of Iowa, its successors or assigns, be, and they are hereby, authorized to construct and maintain a bridge and approaches thereto, over the Mississippi River, at a location suitable to the interests of navigation from a point in or near the city of Lyons, Iowa, to the opposite shore of said river, in the State of Illinois. Said bridge shall be constructed to provide for the safe and convenient passage of wagons, road-way vehicles of all kinds, animals, and foot-passengers, and, at the option of said corporation, its successors or assigns, may be so constructed as to provide

for and be used for the passage of railroad trains, for such reasonable rates or tolls as may be fixed from time to time by said corporation, its successors or assigns, and subject to approval and change by the Secretary of War."

Strike out section two of said act and insert in lieu thereof the following:

SEC. 2. That any bridge built under the provisions of this act may, at the option of the company building the same, be built with unbroken and continuous spans, or as a draw-bridge, or as a ponton draw-bridge: *Provided*, That if said bridge shall be made with unbroken and continuous spans it shall have one or more channel spans, each giving not less than three hundred and fifty feet clear channel way, and not less that fifty-five feet clear head room above high-water mark, and the clear head room under other than channel spans may be less than fifty-five feet, but no part of the superstructure of such spans shall be less than ten feet above high-water mark: *Provided*, That the interests of navigation be not injured by such reduction of height: *And provided further*, That if any bridge built under the provisions of this act shall be constructed as a draw-bridge, it shall have two or more draw-openings, each giving not less than two hundred feet clear channel way, and, in addition to said draw-openings, shall have one or more fixed channel spans, each giving not less than three hundred and fifty feet clear channel way, and every part of the superstructure of draw-bridges shall give a clear head room of not less than ten feet above high-water mark: *And provided further*, That if any bridge built under the provisions of this act shall be constructed as a ponton draw-bridge, it shall be built subject (except as herein modified) to all the terms, requirements, and limitations contained in the act entitled "An act to legalize and establish a ponton railway bridge across the Mississippi River at Prairie du Chien, and to authorize the construction of a similar bridge at or near Clinton, Iowa," approved June sixth, eighteen hundred and seventy-four, so far as they may be applicable thereto: *And provided, also*, That it shall be constructed with one suitable ponton draw giving not less than five hundred feet clear channel way, and such other ponton draws and other openings as may, in the opinion of the Secretary of War, be necessary: *And provided further*, That the piers of any bridge authorized by this act shall be parallel with the current of the river and the bridge itself at right angles thereto, and the spans of any such bridge shall be so located as to afford the greatest possible accommodation to the river traffic, and the drawspans of any such bridge shall be opened promptly by steam or other reliable mechanical power upon reasonable signal for the passage of boats: *And provided further*, That the dimensions of all spans, not definitely fixed by this act, shall be such as in the opinion of the Secretary of War, will best serve the interests of navigation: *And provided further*, That for any two adjacent draw-openings, of two hundred feet each, one draw-opening of three hundred feet may be substituted, if the interests of navigation be not injured thereby: *And provided further*, That if the physical characteristics of the locality where a bridge authorized by this act is to be constructed require, and the interests of navigation be not injured thereby, the length of the fixed openings or the number of draw-openings required by this act may be reduced by the Secretary of War.

Strike out section four of said act and insert in lieu thereof the following:

"SEC. 4. That if any bridge built under the provisions of this act shall be constructed to provide for the passage of railroad trains, all railroad and other companies desiring to use the same shall have and be entitled to equal rights and privileges in the passage of the same, and in the use of the machinery and fixtures thereof, and all approaches thereto, under and upon such terms and conditions as shall be prescribed by the Secretary of War, upon hearing the allegations and proofs of the parties, in case they shall not agree."

Approved, March 15, 1890.

AN ACT to amend an act entitled "An act to authorize the building of a railroad bridge at Fort Smith, in the State of Arkansas," approved July nineteenth, eighteen hundred and eighty-eight.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That an act entitled "An act to authorize the building of a railroad bridge at Fort Smith, in the State of Arkansas," approved July nineteenth, eighteen hundred and eighty-eight, be, and the same is hereby, revived, and declared to be in full force and effect from and after the passage of this act. And section seven of said act, which provides that said act shall be null and void if actual construction of the bridge therein authorized be not commenced within one year, and completed within three years from the date thereof, shall be, and the same is hereby, so amended, that the time within which said bridge is required to be commenced, shall be one year from the passage of this act, and the time within which it is required to be completed shall be three years from the date of the passage of this act.

Approved, March 15, 1890.

AN ACT to authorize the construction of a bridge over the Arkansas River, in the Indian Territory.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Kansas and Arkansas Valley Railway, a corporation organized and existing under the laws of the State of Arkansas, and being empowered by act of Congress, approved June first, eighteen hundred and eighty-six, to construct its railway from a point on the eastern boundary line of the Indian Territory, at or near Fort Smith, Arkansas, through said Territory in a northwest direction to a point on the northern boundary line of said Territory, with the power to build a branch as therein provided, the construction and operation of which said line of railway involves the necessity of constructing a bridge across the Arkansas River, in the Indian Territory, from a point at or near Fort Smith be, and the said Kansas and Arkansas Valley Railway, its successors and assigns, are hereby authorized and empowered to construct said bridge across said river, and to maintain and operate the same as a railway, passenger, and wagon bridge.

SEC. 2. That any bridge authorized to be constructed under this act, whether constructed as a high bridge or a draw bridge, shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe, and to secure that object said company or corporation shall submit to the Secretary of War a design and drawings of said bridge to be erected for his examination and approval and a map of its location, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject, and until said plan and location of said bridge are approved by the Secretary of War said bridge shall not be commenced or built; and should any change be made in the plan of any bridge authorized to be constructed by this act during the progress of the work of construction, such change shall be subject to the approval of the Secretary of War. That all railway companies desiring to use said bridge shall have and be entitled to equal rights and privileges in the passage of the same, and in the use of the machinery and fixtures thereof, and of all approaches thereto, under and upon such terms and conditions as shall be prescribed by the Secretary of War upon hearing the allegations and proofs of the parties, in case they shall not agree.

SEC. 3. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which no higher charge shall be made for transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroad or public highways leading to the said bridge; and it shall enjoy the rights and privileges of other post-roads of the United States.

SEC. 4. That the charges for transportation of passengers and freight in the cars of said company over said bridge shall be subject to, and regulated by, the provisions of section four of the above-recited act of June first, eighteen hundred and eighty-six, authorizing the construction of said railroad in the Indian Territory. The rates of toll which shall be charged for vehicles and foot-passengers over said bridge shall be the same as those now established for like service by the laws of Arkansas, as expressed in section five thousand five hundred and forty-six of Mansfield's Digest thereof, eighteen hundred and eighty-four, page one thousand and sixty-eight.

SEC. 5. That the right to alter, amend, or repeal this act, or any part thereof, whenever Congress shall consider it necessary for the public interest, is hereby expressly reserved, and any expenditure required by reason of such legislation by Congress shall be made by the owners of said bridge, or the corporation or parties controlling and using the same, without cost or damage to the United States.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date of approval of this act.

Approved, March 15, 1890.

AN ACT making an appropriation for the removal of a dangerous obstruction to the entrance of the harbor at Milwaukee, Wisconsin.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is hereby appropriated, out of any money in the Treasury not otherwise appropriated, the sum of six thousand one hundred dollars, or so much thereof as may be necessary, for the purpose of removing the sand-bars formed at the entrance or mouth of the harbor at Milwaukee, Wisconsin, and to make the same free and easy of access or passage by boats arriving at or departing from such port.

Approved March 17, 1890.

AN ACT to authorize the Oregon and Washington Bridge Company to construct and maintain a bridge across the Columbia River, between the State of Oregon and the State of Washington, and to establish it as a post-road.

Whereas the act of Congress approved July sixteenth, eighteen hundred and eighty-eight (twenty-fifth Statutes at Large, page two hundred and ninety-six), has become null and void by failure of the Columbia River Bridge Company, the corporation in said act named, or its assigns, to commence the construction of the bridge in said act authorized within one year from date of said act: Therefore

Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, That the Oregon and Washington Bridge Company, a corporation organized and existing under the laws of the State of Oregon, its successors and assigns, be, and is hereby, authorized to construct and maintain a bridge across the Columbia River, at a place suitable to commerce and not interfering with navigation at a point at or near La Camas, in the State of Washington, and to lay on or over said bridge a track or tracks for the more perfect connection of any railroad or railroads that are or shall be constructed to said river, on either or both sides thereof, at or opposite said point, under the limitations and conditions hereinafter provided; that said bridge shall not interfere with the free navigation of said river, and in case of any litigation arising from any obstruction, or alleged obstruction to the free navigation of said river by reason of the construction of said bridge, the cause may be tried before the circuit court of the United States in and for any district in whose jurisdiction any portion of said obstruction or bridge may be. Said bridge shall be constructed to provide for the passage of railroad trains, and, at the option of the said company, or corporation, its succesors and assigns, for the safe and convenient passage of wagons and vehicles of all kinds, animals, and foot-passengers, for such reasonable rates of toll as may be fixed from time to time by the Secretary of War.

SEC. 2. That said bridge shall be provided with two or more draw openings, each having not less than two hundred feet clear channel-way; and in addition to said draw openings one or more fixed channel-spans, each having not less than three hundred and fifty feet clear channel-way; and every part of the superstructure of said bridge shall give a clear head room of not less than ten feet above extreme known high water mark: *Provided*, That all spans shall be so located as to afford the greatest possible accommodation to the river traffic, and a draw-opening shall, if practicable, be located next or near shore: *Provided, also*, That if the physical characteristics of the locality so require, and the interests of navigation be not injured thereby, the length of the fixed spans or the number of draw-openings may be reduced: *Provided, also*, That for any two adjacent draw-openings of two hundred feet each, one draw-opening of three hundred feet may be substituted if in the opinion of the Secretary of War the interests of navigation be not injured thereby.

SEC. 3. That all draw-spans authorized by this act shall be operated by steam or other reliable mechanical power, and shall be opened promptly upon reasonable signal for the passage of boats, except when trains are passing over said span or spans; but in no case shall unnecessary delay occur in opening said draw after the passage of trains; and, also, that in case the opening of a draw is delayed by reason of the passing of a train after the signal has been given from a boat ready to pass through, the draw shall be opened for the passage of such boat before another train is allowed to pass over the said span or spans; nor shall there be any unnecessary delay in the passage of trains over the bridge.

SEC. 4. That all piers shall be built parallel with the current of the river at that stage of water which is most important for navigation, and the bridge itself shall be built as nearly as may be at right angles thereto; and that riprapping or other protection for imperfect foundations which will lessen the required water-way shall not be permitted; and also that piers which will produce cross-currents or bars dangerous to navigation shall not be constructed; and if after construction any piers or accessory works are found to produce the above mentioned effects, or if any riprapping or other protection prohibited by this section is found to exist, the nuisance shall be abated or corrected under the direction of the Secretary of War and at the expense of the company or persons owning, controlling, or operating said bridge.

SEC. 5. That the approaches to said bridge shall be so designed and constructed as not to interfere with the free discharge of said river in seasons of flood; and any encroachment on the high-water cross-section by piers, solid embankments, or otherwise which will result in unduly accelerating the high-water current at the site of the bridge shall not be allowed.

SEC. 6. That any corporation, company, or persons owning, controlling, or operating the bridge built under the authority of this act shall build and maintain at all times, as accessory works to such bridge, such booms, piers, dikes, guard fences, and similar devices as may be necessary to insure at all times a permanent channel for a suffi-

cient distance above and below the bridge site, and for the guiding of rafts, steam-boats, and other water craft safely under or through said bridge; and if at any time after the construction of the bridge and its accessory works the approaches to draw openings, channel-spans, or raft passages in said bridge are found to be dangerous or difficult of access by any important class of river traffic, the Secretary of War may, upon the recommendation of the Chief of Engineers, United States Army, order the corporation, company, or persons owning, controlling, or operating said bridge to construct under his directions, and to maintain such additional sheer-booms, dikes, and other devices as will obviate the difficulty mentioned, which additional sheer-booms, dikes, and other devices shall be built and maintained at their own expense by said company or persons; and that said company or persons shall maintain at their own expense, from sunset to sunrise throughout the season of navigation, such lights and other signals on said bridge as may be required by the Light-House Board for the security of navigation.

SEC. 7. That the bridge authorized to be constructed by this act shall be located and built under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object said corporation shall submit for his examination a design and drawings of the bridge, piers, approaches, and accessory works, and a map of the location giving, for a space of at least three miles above and one mile below the proposed location the topography of the banks of the river and the shore-lines at high and low water. This map shall be accompanied by others drawn on the scale of one inch to two hundred feet, giving for a space of one-half a mile above the line of the proposed bridge and one-quarter of a mile below an accurate representation of the bottom of the river by contour lines two feet apart, determined by accurate soundings, and also showing over the whole width of this part of the river the force and directions of the currents at low water, at high water, and at least one intermediate stage by triangulated observations on suitable floats. The map shall also show the location of other bridges in the vicinity, and shall give such information as the Secretary of War may require for a full and satisfactory understanding of the subject, and the construction of the proposed bridge shall not be commenced until the location and plans thereof are approved by the Secretary of War.

SEC. 8. That any bridge constructed under the authority of this act shall be built under the general supervision of the Secretary of War, and no changes or alterations in plans shall be made during construction of said bridge or after its completion, unless said changes or alterations conform to the provisions of this act and are authorized by the Secretary of War. That such alterations and changes as may be required by the Secretary of War in said bridge so as to preserve free and convenient navigation shall be made, under the direction of the Secretary of War, at their own expense by the company or persons owning, controlling, or operating said bridge. That during original construction or in carrying out any authorized changes or repairs of said bridge a navigable channel shall be preserved at the site of the bridge at all times, and the water-way of the river shall not be obstructed to a greater extent than is absolutely necessary, and such lights and bouys shall be kept on all coffer-dams, piles, and so forth, as may be necessary, for the security of navigation.

SEC. 9. That whenever the Secretary of War has good reason to believe that any of the provisions of sections four, six, and eight of this act have not been complied with by the company or persons owning, controlling, or operating the bridge authorized under its provisions, it shall be the duty of the Secretary of War, on satisfactory proof thereof, to require the said company or persons to comply with the provisions of said sections, and on failure of said persons or company to comply with said requirements within a reasonable time the Secretary of War shall proceed to cause the necessary work, in the form of additions, alterations, repairs, or removals of obstructions, to be made at the expense of the United States, and shall refer the matter, without delay, to the Attorney General of the United States, whose duty it shall be to institute, in the name of the United States, proceedings in the circuit court of the United States, in and for the District in which any portion of said obstruction or bridge may be for the recovery of such expenses, and all moneys accruing from such proceedings shall be covered into the Treasury of the United States.

SEC. 10. That all railroad companies desiring the use of the bridge authorized by this act shall have, and be entitled to, equal rights and privileges relative to the passage of railway trains or cars over the same, and over the approaches thereto, upon the payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies.

SEC. 11. That the bridge constructed, maintained, and operated under this act and according to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transportation over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation of said mails, troops, and munitions over the railroads and public highways leading to said bridge; and the United States shall have the right of way for postal telegraph and telephone purposes over said bridge.

SEC. 12. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years and completed within four years from the date of approval thereof.

SEC. 13. That all former acts or parts of acts granting authority for the erection of any bridge or bridges over the portion of said Columbia River over which the construction of a bridge is authorized by this act be, and the same are hereby, repealed in each and every case where actual construction of said bridge or bridges be not commenced on or before the date of the approval of this act.

SEC. 14. That the right to alter, amend, or repeal this act is hereby expressly reserved; and the right to require the entire removal of the bridge constructed under the provisions of this act at the expense of the owners thereof, whenever Congress shall decide that the public interests require it, is also expressly reserved.

Approved, March 24, 1890.

AN ACT to authorize the construction of a bridge across the Missouri River between the city of Pierre, in Hughes County, and Stanley County, in the State of South Dakota.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Pierre Ponton Bridge Company, a corporation duly organized and existing under the laws of the State of South Dakota, its successors, or assigns, be, and are hereby, authorized to construct and maintain a bridge, and approaches thereto, across the Missouri River between the city of Pierre, in the State of South Dakota, and Stanley County, in the State of South Dakota.

Said bridge shall be constructed to provide for the passage of railroad trains, wagons, and vehicles of all kinds, steam and street cars, animals, foot-passengers, and for all road travel, for such reasonable rate of toll and under such reasonable rules and regulations as may be prescribed by said corporation, its successors, or assigns, and approved by the Secretary of War.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroad or public highways leading to said bridge, and it shall enjoy the rights and privileges of other post-roads in the United States; and equal privileges in the use of said bridge shall be granted to all telegraph companies, and the United States shall have the right of way across said bridge, and its approaches, for postal telegraph purposes.

SEC. 3. That said bridge shall be constructed as a ponton draw-span bridge, and shall contain a ponton draw-span of not less than three hundred feet in length, which draw-span shall be maintained over the main channel of the river at an accessible and navigable point, and the piers of said bridge shall be parallel with and the bridge itself at right angles to the current of the river: *Provided*, That said draw shall be opened promptly by said company or corporation upon reasonable signal for the passage of boats and rafts and said company or corporation shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light House Board shall prescribe. No bridge shall be erected or maintained under the authority of this act which shall at any time obstruct the free navigation of said river, and if any bridge erected under such authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause the entire removal thereof or such change or alteration of said bridge to be made as will effectually obviate such obstruction, and all such alterations shall be made and all such obstructions shall be removed at the expense of the owner or owners of said bridge, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the case may be brought in the district court of the United States of the State of South Dakota in whose jurisdiction any portion of said obstruction or bridge may be located: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of the law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operations of the same: *Provided*, That said company may construct a wagon and foot bridge alone, and in case of the construction of a wagon and foot bridge alone the draws shall be of the same length

herein provided, and shall be of such construction as shall be approved by the Secretary of War, and shall be subject to all the provisions herein contained in respect to being promptly opened to admit of the unobstructed navigation of said river, and of keeping the same lighted as herein provided in case of a railroad and wagon bridge, and in such case the provisions herein in relation to the use for railroad purposes shall not apply.

SEC. 4. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railroad trains or cars over the same, and over the approaches to the same, upon the payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them, desiring such use, shall fail to agree upon the sum or sums to be paid, and upon the rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

SEC. 5. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his approval and examination, a design and drawings of the bridge, and a map of the location, giving, for the space of one-half mile above and one half mile below the proposed location the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be commenced or built, and should any change be made in the plans of said bridge during the progress of its construction, such changes shall be subject to the approval of the Secretary of War.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the time this act shall take effect: *Provided*, That Congress reserves the right to alter, amend, or repeal this act whenever it may think the public interests so require.

Approved, March 24, 1890.

AN ACT authorizing the purchase of tents by the Secretary of War, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized to purchase twenty-five hundred tents, or so many thereof as may be necessary, for the use of the people driven from their homes in the States of Arkansas, Mississippi, and Louisiana by the present floods prevailing in said States.

SEC. 2. That said tents shall be loaned to the authorities of said States for the purposes aforesaid, at the discretion of the Secretary of War.

SEC. 3. That twenty-five thousand dollars, or so much thereof as may be necessary, be, and the same is hereby, appropriated, out of any money in the Treasury not otherwise appropriated, to pay for the said tents herein authorized to be purchased; and this appropriation shall be available upon the passage of this act.

Approved, March 31, 1890.

AN ACT to provide for certain of the most urgent deficiencies in the appropriations for the service of the Government for the fiscal year ending June thirtieth, eighteen hundred and ninety, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums, or so much thereof as may be necessary, be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, for the objects hereinafter expressed, for the service of the fiscal year eighteen hundred and ninety, and prior years, namely:

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WAR DEPARTMENT.

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ENGINEER DEPARTMENT.

CONSTRUCTING PIER IN DELAWARE BAY, NEAR LEWES, DELAWARE: For repairs, ten thousand dollars.

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Approved, April 4, 1890.

AN ACT to authorize the construction of a railroad bridge across the Missouri River, in the county of Monona, in the State of Iowa, and in the county of Burt, in the State of Nebraska.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Iowa and Decatur Bridge Company, a corporation organized under the laws of the State of Iowa, its successors and assigns, be, and they are hereby, authorized to construct and maintain a railroad bridge over the Missouri River from and through section numbered seven, in township numbered eighty-three north of range forty-six west of the principal meridian, in the county of Monona, State of Iowa, and in and through the county of Burt, in the State of Nebraska.

SEC. 2. That any bridge built under the provisions of this act shall be built as a high bridge, with unbroken and continuous spans, all spans over the water-way to have a clear channel-way of not less than three hundred feet and a clear head room of not less than fifty feet above high-water mark; and the piers of said bridge shall be parallel with the current of the river, and the bridge itself at right angles thereto: *Provided,* That if actual construction of the bridge herein authorized shall not be commenced within two years from the passage of this act, and be completed within four years from the same date, the rights and privileges herein granted shall cease and be determined.

SEC. 3. That any bridge constructed under this act and according to its limitations shall be a lawful structure, and shall be known as a post-route, and the same is hereby declared to be a post-route, upon which no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States, and for passengers or freight passing over said bridge than the rate per mile paid for their transportation over the railroads and public highways leading to said bridge; and equal privileges in the use of said bridge shall be granted to all telephone and telegraph companies, and the United States shall have the right of way for postal telegraph purposes across said bridge.

SEC. 4. That all railway companies desiring to use said bridge shall have and be entitled to equal rights and privileges in the passage of the same, and in the use of the machinery and fixtures thereof, and of all the approaches thereto, under and upon such terms and conditions as shall be prescribed by the Secretary of War, upon hearing the allegations and proofs of the parties, in case they shall not agree.

SEC. 5. That the structure herein authorized shall be built and located under and subject to such regulations for the security of the navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War for his examination and approval a design and drawing of the bridge and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore-line at high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War, the bridge shall not be commenced or built; and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War; and the said bridge shall be constructed with such aids to the passage of said bridge, in the form of booms, dikes, piers, or other suitable and proper structures for confining the flow of water to a permanent and easily navigated channel for a distance of not less than one mile above the bridge location, and for the guiding of rafts, steam-boats, and other craft safely through the draw and raft spars as the Secretary of War shall prescribe and order to be constructed and maintained, at the expense of the company owning said bridge; and the said structure shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said structure; and for the safety of vessels passing at night there shall be displayed on said bridge, from the hours of sunset to sunrise, such lights as may be prescribed by the Light-House Board; and the said structure shall be changed or removed at the cost and expense of the owners thereof as the Secretary of War may direct, so as to preserve the free and convenient navigation of said river; and the authority to erect and continue said bridge shall be subject to revocation and modification by law, when the public good shall, in the judgment of the Secretary of War, so require, without any expense or charge to the United States.

SEC. 6. That said company or its successors may construct and maintain defensive and corrective works in or along said river above and below said bridge, for the protection of the same, and the approach thereto, or the improvement, correction, or control of the channel of said river.

SEC. 7. That in case the western end of said bridge shall abut upon the Omaha Indian Reservation in the State of Nebraska the right to construct the same thereon and the approaches thereto, together with all structures proper for the construction, mainte-

nance, and operation of said bridge is hereby granted and conferred: *Provided*, That compensation therefor shall first be made to the Indians holding in severalty or by allotment the lands upon or over which said approaches, tracks, or structures are erected, built, and maintained, to their satisfaction, or to the satisfaction of the Secretary of the Interior, or by proceedings for condemnation in the usual manner under the laws of the State of Nebraska.

SEC. 8. That the right to alter, amend, or repeal this act is expressly reserved.

Approved, April 9, 1890.

AN ACT to authorize the building of a bridge across White River, Arkansas, by the Mississippi and Little Rock Railway Company.

Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, That it shall be lawful for the Mississippi and Little Rock Railway Company, a corporation created and existing under and by virtue of the laws of the State of Arkansas, its successors and assigns, to erect, construct, and maintain a bridge over the White River in sections sixteen and twenty-one, in township one south, range three west. Said bridge shall be constructed to provide for the passage of the railway trains, and, at the option of the corporation, or its assigns, by which it may be built, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, foot-passengers, and of all kinds of commerce, travel or communication.

SEC. 2. That any bridge built under the act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no other charges shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States, or for passengers or freight passing over said bridge than the rate per mile paid for the transportation over the railroad or public highways leading to said bridge, and it shall enjoy the rights and privileges of other post-roads in the United States; and equal privileges in the use of said bridge shall be granted to all telegraph companies; and the United States shall have the right of way across said bridge and its approaches for postal telegraph purposes.

SEC. 3. That said bridge may be constructed as a draw-bridge, with an opening over the center of the channel of such width as the Secretary of War shall determine, and which shall be at least one hundred and twenty feet in the clear: *Provided, also*, That said draw shall be opened promptly upon reasonable signal for the passage of boats, vessels, or other water-craft, and in no case shall unnecessary delay occur; and said company or corporation shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe, and such sheer-booms or other structures as may be necessary to safely guide vessels, boats, rafts, or other water-craft safely through said draw openings as shall be designated and required by the Secretary of War.

SEC. 4. That said bridge shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe, and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge and a map of the location, giving for the space of one mile above and one mile below the proposed location the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the current at all stages, and the sounding accurately showing the bed of the stream, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location are approved by the Secretary of War the bridge shall not be built, and should any changes be made in the plan of said bridge during the progress of construction, such change shall be submitted to the approval of the Secretary of War.

SEC. 5. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains, engines, or cars over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use, and in case the owner or owners of said bridge, and the several railroad companies, or any one of them, desiring such use, fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War, upon a hearing of the allegations and proofs of the parties: *Provided*, That the provisions of section two, in regard to charges for passengers and freight across said bridge, shall not govern the Secretary of War in determining any question arising as to the sum or sums to be paid to the owners of said bridge by such railroad companies for the use of said bridge.

SEC. 6. That the right to alter, amend, or repeal this act or to require any changes in such structure, or its entire removal at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest requires it, and the right to pre-

scribe such rules and regulations in regard to toll and otherwise, as may be deemed reasonable, are expressly reserved.

SEC. 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years and completed within five years from the date hereof.

Apppoved, April 9, 1890.

AN ACT authorizing the construction of a free bridge across the Arkansas River, connecting Little Rock and Argenta, Arkansas.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the county of Pulaski, State of Arkansas, to build a free foot, wagon, and street-railway bridge across the Arkansas River, at the city of Little Rock, in Arkansas; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river by reason of the construction of said bridge, the cause may be tried before the district court of the United States having jurisdiction over that portion of the State of Arkansas where said bridge shall be located.

SEC. 2. That if any bridge built under the provisions of this act shall be constructed as a draw-bridge, the same shall be constructed as a pivot draw-bridge, with a draw over the main channel of the river, at an accessible and navigable point, and with the spans of not less than one hundred and sixty feet in length in the clear, on each side of the central or pivot pier of the draw; and the next adjoining spans to the draw shall not be less than two hundred and fifty feet; and said span shall not be less than twenty feet above high-water mark, measuring to the bottom chord of the bridge: *And provided also*, That said draw shall be opened promptly upon reasonable signal for the passage of boats whose construction shall not be such as to admit of their passage under the permanent spans of said bridge; and the bridge-piers shall be parallel to the current of the river.

SEC. 3. That any bridge constructed under this act and according to its limitations, shall be a lawful structure and shall be recognized and known as a post-route, upon which no charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States.

SEC. 4. That the United States shall have the right of way for postal telegraph purposes across said bridge. And all telegraph and telephone companies shall have equal rights and privileges as to constructing their lines across said bridge.

SEC. 5. That the said county of Pulaski shall submit to the Secretary of War, for his approval, a plan with the necessary drawings of the said bridge conforming to the above requirements, and until the Secretary of War approve the plan and location of said bridge and notify the county court of the said county of the same in writing, the bridge shall not be built or commenced; and should any change be made in the plan of the bridge during the progress of the work thereon, such change shall be subject likewise to the approval of the Secretary of War.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year, and completed within three years from the approval of this act.

SEC. 7. That Congress shall have power at any time to alter, amend, or repeal this act, or any part thereof, if, in its judgment, the public interests so require, and any change in the construction of the bridge hereby authorized made necessary by the action of Congress, or the entire removal of the same, if required, shall be at the expense of the owners of said bridge, or the parties controlling and using the same.

Approved, April 9, 1890.

AN ACT to authorize the construction of a bridge across the Arkansas River at or near Pendleton, Desha County, Arkansas.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Arkansas and Gulf Railroad Company, a corporation organized, chartered, and duly perfected under and in full accordance with the statutes of the State of Arkansas, or its successors or assigns, to construct and maintain a bridge and approaches thereto over the Arkansas River, at a point on said river at or near Pendleton, Desha County, in the State of Arkansas, and to lay on and over said bridge a railroad track or tracks, for the more perfect connection of any railroad or railroads that are or shall hereafter be constructed to the said river, on either or both sides thereof, at or opposite said point, under the limitations and conditions hereinafter provided; said bridge shall be constructed to provide for the passage of railway

trains, and, at the option of the builders and owners thereof, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals of all kinds, and for foot-passengers for such reasonable rates of toll as may be approved, from time to time, by the Secretary of War.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, troops, and the munitions of war, or other property of the United States, than the rate per mile paid for the transportation of the same over the railroad or public highways leading to the said bridge, and it shall enjoy the rights and privileges of other post-roads in the United States. Equal privileges in the use of said bridge shall be granted to all telegraph companies; and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes.

SEC. 3. That the said bridge shall be constructed with a draw or pivot span, which shall be over the main channel of the river at an accessible navigable point, and the openings on each side of the pivot-pier shall be of such width as the Secretary of War shall prescribe, and, as nearly as practicable, both of said openings shall be accessible at all stages of water; that the spans shall be of such height above extreme high-water mark, as understood at the point of location, to the lowest point of the superstructure of said bridge as may be directed by the Secretary of War in the interests of navigation; that the piers and draw-rests of said bridge shall be built parallel with the current at that stage of the river which is most important for navigation, and the bridge itself at right angles thereto; and that no riprap or other outside protection for imperfect foundations be permitted to approach nearer than four feet to the surface of the water at its extreme low stage or otherwise to encroach upon the channel-ways provided for in this act: *Provided*, That said draw shall be opened by the company or persons owning said bridge upon reasonable signal for the passage of boats, and there shall be maintained, at the expense of the owners thereof, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe.

SEC. 4. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same, and over the approaches to the same, upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon rules and conditions which each shall perform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon hearing of the allegations of proofs of the parties.

SEC. 5. That any bridge authorized to be constructed under this act shall be built and located under and subject to the regulations for the security of said river as the Secretary of War shall prescribe; and to secure that object the owner or owners thereof shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shoreline at high or low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for the full and satisfactory understanding of the subject; and until such plan and location of the bridge are approved by the Secretary of War the bridge shall not be commenced or built, and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War.

SEC. 6. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in said structure, or its entire removal, at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest requires it, is also expressly reserved.

SEC. 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years and completed within five years from the date thereof.

Approved, April 9, 1890.

AN ACT to amend article one hundred and three of the Rules and Articles of War.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the one hundred and third article of the Rules and Articles of War be, and the same is hereby, amended by adding thereto the following words:

"No person shall be tried or punished by a court-martial for desertion in time of peace and not in the face of an enemy, committed more than two years before the ar-

raignment of such person for such offense, unless he shall meanwhile have absented himself from the United States, in which case the time of his absence shall be excluded in computing the period of the limitation: *Provided*, That said limitation shall not begin until the end of the term for which said person was mustered into the service."

Approved, April 11, 1890.

AN ACT for the relief of soldiers and sailors who enlisted or served under assumed names, while minors or otherwise, in the Army or Navy, during the war of the rebellion.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War and the Secretary of the Navy be, and they are hereby, authorized and required to issue certificates of discharge or orders of acceptance of resignation, upon application and proof of identity, in the true name of such persons as enlisted or served under assumed names, while minors or otherwise, in the Army and Navy during the war of the rebellion, and were honorably discharged therefrom. Applications for said certificates of discharge or amended orders of resignation may be made by or on behalf of persons entitled to them; but no such certificate or order shall be issued where a name was assumed to cover a crime or to avoid its consequence.

Approved, April 14, 1890.

AN ACT to amend and continue in force "An act to authorize the construction of a bridge across the Missouri River at Forest City, Dakota, by the Forest City and Watertown Railway Company," approved August sixth, eighteen hundred and eighty-eight.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for the commencement and completion of the bridge authorized by the act of Congress entitled "An act to authorize the construction of a bridge across the Missouri River at Forest City, Dakota, by the Forest City and Watertown Railway Company," approved August sixth, eighteen hundred and eighty-eight as provided for in section seven thereof, be, and it is hereby, extended two years from the date of the passage of this act.

SEC. 2. That wherever in said act the term "Territory of Dakota" is used it shall be held to mean and shall read "State of South Dakota."

SEC. 3. That so much of said act as authorizes the said bridge to be built as a draw-bridge be, and the same is hereby, repealed, and any bridge constructed under the authority granted by said act shall be built as a high bridge.

Approved, April 18, 1890.

AN ACT to authorize the Natchitoches Cane River Bridge Company to construct and maintain a bridge across Cane River, in Louisiana.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Natchitoches Cane River Bridge Company, a corporation created and existing under and by virtue of the laws of the State of Louisiana, be, and is hereby, authorized to construct and maintain a wagon bridge across the Cane River at such point as may be selected by the said bridge company within the limits of the town of Natchitoches, the said bridge to be so constructed as not to interfere with the navigation of said river, and to be provided with a suitable draw: *Provided*, That any bridge constructed under this act and according to its limitations shall be a lawful structure, and shall be known and recognized as a post-route, and the same is hereby declared to be a post-route, and the United States shall have the right of way for a postal telegraph across said bridge.

SEC. 2. That the bridge authorized to be constructed under this act shall be located and built under and subject to such regulations for the security of the navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the proposed bridge, and a map of the location, giving, for the space of one-half mile above and one-half mile below the proposed location, the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the currents, and the soundings, accurately showing the bed of the stream, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War no work upon the bridge shall be commenced; and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War.

SEC. 3. That Congress reserves the right to alter, amend, or repeal this act at any time; and that if at any time navigation of the said river shall in any manner be obstructed or impaired by the said bridge, the Secretary of War shall have authority, and it shall be his duty, to require the said bridge company to alter and change the said bridge at its own expense, in such manner as may be proper to secure free and complete navigation without impediment; and if upon reasonable notice to said bridge company to make such change or improvements the said company fails to do so, the Secretary of War shall have authority to make the same at the expense of said company, and all the rights conferred by this act shall be forfeited; and Congress shall have power to do any and all things necessary to secure the free navigation of the river.

SEC. 4. That said company shall be permitted to charge and take such rates of toll for crossing said bridge as may be reasonable, subject to the approval of the Secretary of War.

SEC. 5. That the draw provided for the bridge herein authorized to be constructed shall be opened promptly upon reasonable signal for the passing of boats; and said company or corporation shall maintain, at its own expense, from sunset till sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe.

SEC. 6. That all telephone and telegraph companies shall be granted equal rights and privileges in the construction and operation of their lines across said bridge; and if actual construction of the bridge herein authorized shall not be commenced within one year from the passage of this act, and be completed within three years from the same date, the rights and privileges hereby granted shall cease and be determined.

Approved, April 22, 1890.

AN ACT to amend an act to authorize the construction of a bridge across Trail Creek, in the city of Michigan City, Indiana.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That an act to authorize the construction of a bridge across Trail Creek, in the city of Michigan City, Indiana, approved June twenty-ninth, eighteen hundred and eighty-eight, be hereby amended by substituting for section two of the aforesaid act the following:

"SEC. 2. That if the construction of the bridge hereby authorized shall not be commenced within two years from the time this act takes effect and be completed within four years after its commencement, then this act shall be void, and all rights hereby conferred shall cease and determine."

SEC. 2. That all acts or parts of acts inconsistent herewith are hereby repealed.

Approved, April 22, 1890.

AN ACT for the construction of a railroad and wagon bridge across the Mississippi River at South Saint Paul, Minnesota.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the South Saint Paul Belt Railroad Company, its successors and assigns, be, and they are hereby, authorized to construct and maintain, at a point suitable to the interest of navigation, a railroad bridge or a combined railroad, wagon, and foot-passenger bridge across the Mississippi River, from a suitable point on its west bank, at or near the city of South Saint Paul, in the State of Minnesota, and within the limits of section thirty-five, township twenty-eight, range twenty-two west, to a corresponding point on its west bank, and to lay on or over said bridge a railroad track or tracks for the more perfect connection of any railroad or railroads that are or shall be constructed to said river, on either or both sides thereof, at or opposite said places, under the limitations and conditions hereinafter provided; that said bridge shall not interfere with the free navigation of said river beyond what is necessary in order to carry into effect the rights and privileges hereby granted; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, or damage resulting from the same, the cause may be tried before the circuit court of the United States in and for any district in which any portion of said bridge or obstruction touches; said bridge may, at the option of the company building the same, be constructed to provide for the passage of railroad trains alone or for the passage of railroad trains and for the safe passage of wagons and vehicles of all kinds, for the transit of animals, and for foot-passengers, all for such reasonable rates of toll as may be fixed from time to time by the Secretary of War.

SEC. 2. That any bridge built under the provisions of this act shall be constructed as a pivot draw-bridge with a draw over the main channel of the river at an accessible and navigable point, and with spans giving a clear width of waterway of not less than two

hundred feet on each side of the central or pivot pier of the draw, and the span or spans adjoining the draw shall give such clear width of water-way as in the opinion of the Secretary of War are required by the interests of navigation, and said spans shall give a clear headroom of not less than ten feet above extreme high water-mark; and the piers of said bridge shall be parallel with the current of the river where said bridge shall be erected: *And provided also*, That said draw shall be operated by steam or other reliable mechanical power and shall be opened promptly upon reasonable signal for the passage of boats, except when trains are passing over the draw; but in no case shall unnecessary delay occur in opening the said draw during or after the passage of trains.

SEC. 3. That any bridge constructed under this act and according to its limitations shall be a lawful structure and shall be known as a post-route, and the same is hereby declared to be a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States, or for passengers or freight passing over said bridge, than the rate per mile paid for their transportation over the railroads and public highways leading to said bridge; and the United States shall have the right of way for postal telegraph purposes across said bridge.

SEC. 4. That all railway companies desiring to use said bridge shall have and be entitled to equal rights and privileges in the passage of the same, and in the use of the fixtures and machinery thereof, and of all the approaches thereto, under and upon such terms and conditions as shall be prescribed by the Secretary of War upon hearing the allegations and proofs of the parties in case they shall not agree.

SEC. 5. That the structure herein authorized shall be built and located under and subject to such regulations for the security of the navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War for examination and approval a design and drawing of the bridge and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are decided by the Secretary of War to be such as will not materially affect the interests of navigation the bridge shall not be commenced or built. And should any change be made in the plan of said bridge during the progress of construction such changes shall be subject to the approval of the Secretary of War; and the said bridge shall be constructed with such aids to the passage of said bridge in the form of booms, dikes, piers or other suituable and proper structures for confining the flow of water to a permanent channel for a distance of not less than one mile above the bridge and for a proper distance below, and for the guiding of rafts, steam-boats, and other water-crafts safely through the draw and raft spans as the Secretary of War shall prescribe and order to be constructed and maintained at the expense of the company owning said bridge; and the said structure shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said structure; and for the safety of vessels passing at night there shall be displayed on said bridge, from the hours of sunset to sunrise, such lights as may be prescribed by the Secretary of War; and a record shall be kept, and posted where it will be plainly visible to boats passing the draw, showing each day the stage of water and whether the river is rising or falling; and the said structure shall be changed or removed at the cost and expense of the owners thereof from time to time, as Congress may direct, so as to preserve the free and convenient navigation of said river; and the authority to erect and continue said bridge shall be subject to revocation and modification by law when the public good shall in the judgment of Congress so require without any expense or charge to the United States.

SEC. 6. That the right to alter, amend, or repeal this act is hereby expressly reserved.

SEC. 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the approval of this act.

Approved, April 26, 1890.

AN ACT granting the counties of Hennepin and Dakota, Minnesota, the right to build two bridges across the Minnesota River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the board of county commissioners of the county of Hennepin and State of Minnesota be, and the same hereby are, authorized to construct and maintain two bridges over the Minnesota River and approaches thereto. One bridge to be located by a majority of the said board of county commissioners of said Hennepin County,

and a majority of the board of county commissioners of the county of Dakota, in said State of Minnesota, either in section thirteen in township twenty-seven, range twenty-four west of the fourth principal meridian; or in section eighteen, township twenty-seven, range twenty-three west of the fourth principal meridian, as in the judgment of said majority of said commissioners shall be the best place for the construction of said bridge and approaches thereto; and one bridge and approaches thereto, between and connecting said Hennepin County and the county of Scott, in said State of Minnesota, at the point or place on said Minnesota River commonly known as and called "Bloomington Ferry" or "Lyndale Avenue," or at any place where said board of county commissioners of Hennepin County may decide between said points. Said bridges and approaches shall be of such plans and material as said board of county commissioners of Hennepin County shall in their discretion determine, except that said bridges shall be constructed as draw-bridges, and shall be and remain forever free. Said bridge or bridges shall be constructed to provide for free passage of wagons and vehicles of all kinds, for the transit of animals and for foot passengers.

SEC. 2. That any bridge built under this act and subject to its limitations, shall be a lawful structure, and shall be recognized as a post-route, and shall enjoy the rights and privileges of other post-roads in the United States: *Provided*, That the United States may construct a postal telegraph over said bridge or bridges without charge therefor.

SEC. 3. That any bridge built under this act shall be constructed as a pivot draw-bridge, with a draw over the main channel at an accessible and the best navigable point, and with draw-spans having a clear water-way, measured at the lowest stage of water known at the locality, of not less than eighty feet in clear width, which shall not thereafter be reduced by deposits of rip-rap, or by other material about the piers and abutments; and the spans shall not be less elevation than ten feet above extreme high-water mark, as shown at the point of location, measuring to the lowest part of the superstructure of said bridge, and provision shall be made in the location and construction of the abutments and approaches to allow the free passage of flood water; and the piers of said bridge shall be parallel to and the bridge itself at right angles to the direction of the current of said stream: *Provided, also*, that the said draw, or draws, shall be opened promptly upon reasonable signal, for the passage of boats, and said board of county commissioners of said Hennepin County shall maintain at the expense of said Hennepin County such lights or other signals thereon as the light-House Board may prescribe, and said Hennepin County shall provide at its own expense such sheer-booms, guide-piers, or other device as may be at any time deemed necessary by the Secretary of War to facilitate the safe passage of boats or other water craft through the spans of said bridge. No bridge shall be erected or maintained under authority of this act which shall at any time substantially or materially obstruct the free navigation of said river; and if any bridge erected under such authority shall in the opinion of the Secretary of War, obstruct said navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstructions, at the expense of said county of Hennepin, and in case of any litigation arising from any obstruction, or alleged obstruction, to the free navigation of said river caused, or alleged, to be caused by said bridges, or either, the case may be brought in the circuit court of the United States of the district in which said obstruction or bridges are located: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt any bridge or bridges constructed by virtue thereof from the operation of the same.

SEC. 4. That any bridge or bridges authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of nagivation of said river as the Secretary of War shall prescribe, and to secure that object the said board of county commissioners of said Hennepin County shall submit to the Secretary of War, for his examination and approval, designs and drawings of the proposed bridges and a map of the location, giving for the space of one mile above and one mile below the proposed locations the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the currents at all stages, and the surroundings, accurately showing the bed of the stream, the location of any other bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and should any change be made in the plan of said bridge or bridges such change shall be subject to the approval of the Secretary of War.

SEC. 5. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in such structure or structures, or the entire removal thereof, at the expense of the owners, whenever Congress shall decide that the public interest requires it, is also expressly reserved.

SEC. 6. That this act shall be null and void if actual construction of the bridges herein authorized be not commenced within one year, and completed within three years from the date thereof

Approved, April 28, 1890.

AN ACT authorizing the construction of a bridge across the Red River of the North.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Crookston, Fort Stevenson and Montana Railroad Company, a corporation existing under the laws of the State of Minnesota, and to its successors and assigns, to construct and maintain a pivot draw-bridge, and approaches thereto, across the Red River of the North, between the State of Minnesota and the State of North Dakota, at such point on said river, on the boundary line between Polk County, in the State of Minnesota, and the State of North Dakota, as may accommodate the lines of railroad which said corporation may build to said point. Said bridge shall be constructed to provide for the passage of railway trains, and, at the option of the said corporation, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot passengers, for such reasonable rates of tolls as may be fixed by the Secretary of War; and the Secretary of War shall have the right, from time to time, to revise such rates.

SEC. 2. That the said bridge shall be constructed as a pivot draw-bridge, and shall be so constructed that a free and unobstructed passage may be secured to all water-craft, rafts, or logs navigating said river at the point aforesaid: *Provided*, That the draw of said bridge shall be opened promptly upon reasonable signals for the passage of boats or vessels; and said corporation shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Secretary of War shall prescribe. The said bridge shall be located and built under and subject to such regulations for the security of the navigation of said river and such requirements as to location and direction of piers and spans clear headway at high water and clear spans at low water, as the Secretary of War shall prescribe; and to secure that object the said company shall submit to the Secretary of War, for his examination and approval, drawings of said bridge and piers, and a map of the location, giving, for the space of one mile below and one mile above the proposed location, the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed and channel of the stream, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until the said location and plan of the bridge hereby authorized to be constructed are approved by the Secretary of War the said bridge shall not be built; and should any change be made in the plan of such bridge during the progress of construction thereof, such change shall be subject to the approval of the Secretary of War.

SEC. 3. That all railroad companies desiring the use of the bridge constructed under this act shall have and be entitled to equal rights and privileges relative to the passage of railway trains, cars, and locomotives over the same, and over the approaches thereto, upon the payment of a reasonable compensation for such use, to be fixed by the Secretary of War, in case the owner or owners of the said bridge and the several railroad companies, or any of them desiring such use, shall fail to agree upon the sum or sums to be paid; and the Secretary of War shall prescribe the rules and conditions to which each shall conform in using said bridge, and all matters of difference between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

SEC. 4. That the bridge authorized to be constructed under this act shall be a lawful structure, and shall be recognized and known as a post-route, and the same is hereby declared to be a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, troops, and munitions of war of the United States, or for through railways passengers or freight passing over said bridge, than the rate per mile for their transmission over the railroads leading to said bridge; and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes and all telegraph or telephone companies shall have equal rights and privileges in constructing and maintaining their lines across said bridge.

SEC. 5. That the right to alter, amend, or repeal this act, so as to prevent or remove all material and substantial obstructions to the navigation of said river by the construction of the said bridge, is hereby expressly reserved; and any alterations or changes that may be required by Congress in the bridge constructed under this act shall be made by the corporation owning or controlling the same, at its own expense.

SEC. 6. That the time within which the construction of said bridge shall be commenced shall be one year and it shall be completed within three years from and after the passage of this act.

Approved, April 28, 1890.

AN ACT to amend an act entitled "An act authorizing the construction of a high wagon-bridge across the Missouri River at or near Sioux City, Iowa," approved March second, eighteen hundred and eighty-nine.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section one of the act entitled "An act authorizing the construction of a high wagon-bridge across the Missouri River at or near Sioux City, Iowa," approved March Second, eighteen hundred and eighty-nine, be amended so that it shall read as follows: "That it shall be lawful for the "Pacific Short Line Bridge Company" to construct and maintain a combined wagon, railroad, and foot-passenger bridge of the kind known as a 'pivot draw-bridge', with one or more draws, as may be prescribed by the Secretary of War, across the Missouri River at or near Sioux City, in the State of Iowa, so as to connect with the opposite shore of the said river in the State of Nebraska, for the passage of wagons, railroad trains, and vehicles of all kinds, for the transit of animals, and for foot-passengers, for such reasonable rates of toll as the city of Sioux City, Iowa, may from time to time prescribe, subject to the approval of the Secretary of War: *Provided*, That said bridge shall not be built or commenced until the plan and specifications for its construction have been submitted to the Secretary of War for his approval, nor until he shall approve the plan and location of said bridge; and if any change be made in the plan of construction of said bridge at any time such change shall be subject to the approval of the Secretary of War; and any change in the construction or any alteration of said bridge that may be directed at any time by Congress or the Secretary of War shall be made at the cost and expense of the owners thereof: *Provided*, That said 'Pacific Short Line Bridge Company' shall, at its own expense, build and maintain, under direction and supervision of the Secretary of War, such wing-dams and booms or other works necessary to maintain the channel within the draw span or spans of said bridge, and shall, at their own expense, maintain a depth of water through said draw span or spans not less than that now existing, as shown by the report of the War Department, at the point where said bridge may be located; and if said Pacific Short Line Bridge Company shall fail to maintain such channel as aforesaid, then the Secretary of War may cause said channel to be opened and maintained at proper depth for navigation through said span or spans at the expense of the owners of said bridge, or may remove obstructions to navigation as provided in section six of said act approved March second, eighteen hundred and eighty-nine.

SEC. 2. That section two of said act be amended by striking out the word "three," in the fourth line of the second proviso, after the word "them" and before the word "hundred," and inserting in lieu thereof the word "two;" also by inserting immediately after the word "clear," in the next line, the words "on each side of the pivot pier," so that the second proviso shall read as follows: "*And provided also*, That if any bridge built under this act be constructed as a drawbridge it shall have a draw over the main channel of the river at an accessible and navigable point, and with a span or spans not less than two hundred feet in length in the clear on each side of the pivot pier."

SEC. 3. That all railroad companies desiring the use of said bridge, approaches, and accessory works shall have and and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them desiring such use, shall fail to agree upon the sum or sums to be paid and upon rules and conditions to which each shall conform in using said bridge, all matters in issue between them shall be decided by the Secretary of War upon reasonable notice to the parties in interest and upon consideration of such allegations and proofs as may be submitted to him.

SEC. 4. That the title of the said act be amended so as to read in lieu thereof: "An act authorizing the construction of a combined wagon, railroad, and foot-passenger bridge, of the kind known as a 'pivot draw-bridge,' across the Missouri River at or near Sioux City, Iowa."

Approved, April 30, 1890.

AN ACT authorizing the Brazos Terminal Railway Company to construct a bridge across the Brazos River in the State of Texas.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Brazos Terminal Railway Company, a corporation incorporated and organized under the laws of the State of Texas, and to its successors and assigns, to construct and maintain a bridge and approaches thereto across the Brazos River, in the State of Texas, between its mouth and a point twelve miles up said river. Said bridge shall be so constructed as to provide for the passage of railway trains, and, at the option of the said corporation, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, and for

foot-passengers, for reasonable rates of toll, to be fixed by said company, and approved by the Secretary of War.

SEC. 2. That any bridge built under this act shall be constructed as a pivot draw-bridge, with a draw over the main channel at an accessible and the best navigable point, and with spans giving a clear water-way, measured at the lowest stage of water known at the locality, of such width and height as the Secretary of War, may, upon examination, prescribe; and the lowest part of the superstructure of the bridge shall be of such elevation above the plane of the highest flood known at the locality as the Secretary of War may deem advisable; and the piers of said bridge shall be parallel to and the bridge shall be at right angles to the current of the river: *Provided*, That the draw shall be opened promptly upon reasonable signal for the passage of boats and other water-craft, except when trains are passing over the draw; but in no case shall unnecessary delay occur in opening the draw during or after the passage of trains; and said corporation shall maintain, at its own expense, from sunset to sunrise, such lights and other signals on said bridge as the Light-House Board shall prescribe, and said corporation shall provide, at its own expense, such sheer-booms, guide-piers, and other devices as may be necessary to facilitate the safe passage of boats or other water-craft through the spans of said bridge. The said bridge shall be located and built under and subject to such regulations for the security of the navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company shall submit to the Secretary of War, for his examination and approval, a design and drawings of said bridge and a map of the location, giving for the space of one mile below and one mile above the proposed location, the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed and channel of the stream, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and, until the said location and plans of the bridge hereby authorized to be constructed are approved by the Secretary of War, the said bridge shall not be built; and should any change be made in the plan of such bridge during the progress of construction thereof, such change shall be subject to the approval of the Secretary of War; and in case of any litigation arising from the obstruction or alleged obstruction caused by said bridge to the free navigation of said river, the cause may be tried before the circuit court of the United States in whose jurisdiction any portion of the bridge is located.

SEC. 3. That the bridge authorized to be constructed under this act shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, troops, and the munitions of war of the United States, or for through railway passengers or freight passing over said bridge, than the rate per mile for their transmission over the railroads leading to said bridge; and equal privileges in the use of said bridge shall be granted to all telegraph companies; and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes.

SEC. 4. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any of them, desiring such use, shall fail to agree upon the sum or sums to be paid and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

SEC. 5. That the right to alter, amend, or repeal this act, whenever Congress shall consider it necessary to the public interest, is hereby expressly reserved; any any alterations or changes that may be required by Congress in the bridge constructed under this act, or the entire removal of said bridge, if required by Congress, shall be made by the corporation owning or controlling the same at its own expense; and if said bridge shall not be commenced in one year and be finished within three years from the passage of this act the rights and privileges hereby granted as to such bridge shall be null and void.

Approved, May 1, 1890.

AN ACT for improving Aransas Pass.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Aransas Pass Harbor Company, a corporation duly chartered under the laws of the State of Texas, and their associates, assigns, successors, and representatives be, and they are hereby, authorized on the conditions hereinafter mentioned, to construct, own, and operate such permament and sufficient jetties and breakwaters

and such auxiliary works as are necessary to create and permanently maintain, as hereinafter set forth, a navigable channel across the outer bar, which obstructs the entrance to Aransas Pass Harbor, on the coast of the Gulf of Mexico, in the State of Texas, and so far into the bays and navigable waters as may be necessary to reach a place that will afford ample dockage and protection from storms, swells, cyclones, and tidal waves for the purpose of furnishing the vessels and boats adapted to the purpose, facilities for navigation in and along the entire length of said channel, and for that purpose they may construct in the Gulf of Mexico and in and across the bays and navigable waters adjacent thereto such walls, jetties, dikes, levees, and other structures, and employ such boats, rafts, bridges, and appliances, as they may in the prosecution of said work deem necessary: *Provided*, That no such structure or means employed shall hinder, delay, or interfere with the free navigation in said channel, harbor, bays, or navigable waters; and to protect their said works they may build and maintain such levees, embankments, walls, or riprap as may be necessary to secure their permanency along the banks or shores of Mustang, Saint Joseph, and Harbor Islands as the United States is authorized to grant, and to utilize such works as the Government has already constructed, and will hold the United States harmless from any damage that may accure to any person or persons by the construction of said walls, jetties, dikes, levees, and other works constructed thereunder: *Provided further*, That unless the construction of the proposed work shall be commenced within one year from date of the approval of this act and be diligently prosecuted by the expenditure of at least three hundred thousand dollars per annum thereafter in the prosecution thereof until twenty feet depth of water over the outer bar is obtained, the grant of privileges herein shall be forfeited; and unless the said company, their associates, assigns, successors, or legal representatives, shall secure a navigable depth over said outer bar of fifteen feet of water within three years after the date of the approval of this act, and a navigable depth of twenty feet of water over said bar within five years from said date, then Congress may revoke the privileges herein granted in relation to said improvements.

SEC. 2. That at any time after said improvements and auxiliary works have been completed as herein provided, and said depth of twenty feet has been obtained, the United States shall have the right to pay the said company, or their assigns, successors, or legal representatives, the value of the works constructed under this act or under or by virtue of any authority granted by the State of Texas, and on such payment being made by the United States all rights to said work on the part of said parties shall cease, but nothing in this act shall be construed as compelling the Government to take possession of and pay for said works unless so desired. Nothing within the provisions of this act shall be construed as authorizing the said company to charge or collect tolls or tonnage upon boats or vessels navigating said channel and the navigation of the same shall be free.

Approved, May 12, 1890.

AN ACT to authorize the construction of a bridge across the Oconee River, in the State of Georgia.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Wrightsville and Tennville Railroad Company, an organization incorporated under the laws of the State of Georgia, its successors and assigns, and such other person or persons as may be associated with it to construct and maintain a bridge over the Oconee River, at or near Dublin, in the State of Georgia.

SEC. 2. That the bridge shall be so constructed by drawspan or otherwise that a free and unobstructed passage may be secured to all vessels and other water craft navigating said river. That any bridge constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe, and to secure that object the said company shall submit to the Secretaro of War, for his examination and approval, the design and drawings of the bridge, piers, and approaches, and a map of the location, giving, for the space of at least one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, and the direction and strength of the currents at all stages, and the soundings accurately showing the bed of the stream, and the location of other bridge or bridges, wharves, landings, or ferries, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until said plan and location of the bridge are approved by the Secretary of War, the bridge shall not be built, and after such approval by the Secretary of War, the approved plans and designs for the bridge shall not be deviated from or added to, either during the construction or after the completion of the bridge, until the proposed change shall have been submitted to the Secretary of War and received his approval;

and the said bridge shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said bridge; and if said bridge be built with a draw, said draw shall be opened promptly upon reasonable signal for the passage of boats, and the said compay or corporation shall maintain at its own expense, from sunset until sunrise, such lights or other signals on said bridge as the Light House Board shall prescribe; and if at any time the navigation of said river shall in any manner be obstructed or impared by the bridge authorized by this act to be constructed, the Secretary of War shall have authority, and it shall be his duty to require said company to alter and change the said bridge, at its own expense, in such manner as may be proper to secure free and complete navigation without inpediment; and if upon reasonable notice to said company to make such change or improvements, the said company fails to do so, the Secretary of War shall have authority to make the same, and all the rights conferred by this act shall be forfeited, and Congress shall have the power to do any and all things necessary to secure the free navigation of the river: *Provided also*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operations of the same.

SEC. 3. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States, or passengers or freight over said bridge, than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge; and they shall enjoy the rights and privileges of other post-roads of the United States. And equal privileges in the use of said bridge shall be granted to all telegraph companies, and the United States shall have the right of way across said bridge and its approaches for said postal telegraph purposes.

SEC. 4. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in said structure, or its removal, at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest requires it, is also expressly reserved.

SEC. 5. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof.

Approved, May 21, 1890.

AN ACT to amend section four of "An act to authorize the county of Laurens, in the State of Georgia to construct a bridge across the Oconee River at or near Dublin, in said county and State," approved June eighteenth, eighteen hundred and eighty-eight.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section four of "An act to authorize the county of Laurens, in the State of Georgia, to construct a bridge across the Oconee River at or near Dublin, in said county and State," approved June eighteenth, eighteen hundred and eighty-eight, which reads as follows: "That if the construction of the bridge hereby authorized shall not be commenced within two years from the time this act takes effect, and be completed within four years after its commencement, then this act shall be void," be, and the same is hereby, so amended as to read as follows: That if the construction of the bridge hereby authorized shall not be commenced within three years from the first day of January, eighteen hundred and ninety-one, and be completed within four years after its commencement, then this act shall be void.

Approved May 23, 1890.

AN ACT to amend an act entitled "An act authorizing the Mississippi and Louisiana Bridge and Railroad Company of Natchez, Mississippi, to construct a bridge over the Mississippi River at or near Natchez, Mississippi," approved July nineteenth, eighteen hundred and eighty-eight.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section twelve of the above-recited act be amended so as to read, "That if the construction of said bridge is not commenced by the first day of January, eighteen hundred and ninety-two, and completed in three years thereafter, all rights hereby conferred shall cease and determine."

Approved, June 10, 1890.

AN ACT to authorize the building of a bridge at Pine Bluff, Arkansas, across the Arkansas River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Cable City Bridge Construction Company, a corporation duly organized and existing under the laws of the State of Missouri, its successors and assigns, be, and are hereby, authorized to construct and maintain a pontoon bridge and approaches thereto across the Arkansas River in front of Pine Bluff, at a point at least one mile from any other bridge, which shall not be detrimental to the interest of navigation or of any river improvement. Said bridge shall be constructed so as to provide for the passsage of wagons and vehicles of all kinds, animals, and foot passengers, and for all road travel, for such reasonable rates of toll as may be fixed by the county court of Jefferson County, Arkansas, and under such reasonable rules and regulations as may be prescribed by said corporation, its successors or assigns, and to be approved from time to time by the Secretary of War.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than is charged other parties for like privileges; and it shall enjoy the rights and privileges of other post-roads in the United States, and the United States shall have the right of way across said bridge and its approaches for postal telegraph purposes. And equal rights as to constructing and maintaining their lines over said bridge shall be granted to all telegraph and telephone companies desiring to use the same.

SEC. 3. That said bridge shall be constructed as a pontoon draw-span bridge, and shall contain a pontoon draw-span of not less than three hundred feet in length, which said draw-span shall be maintained on the main channel of the river at an accessible and navigable point; and the piers of said bridge shall be parallel with, and the bridge itself at right angles to, the current of the river: *Provided also*, That said draw shall be opened promptly by the said company upon a reasonable signal for the passage of boats and rafts; and said company or corporation shall maintain, at their own expense, from sunset to sunrise, snch lights or other signals on such bridge as the Light-House Board shall prescribe. No bridge shall be constructed or maintained under the authority of this act which shall at any time substantially or materially obstruct the free navigation of said river; and if any bridge erected under said authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction; and all such alterations shall be made and all such obstructions be removed at the expense of the owner or owners of said bridge; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, suit may be brought in the district court of the United States of the eastern district of the State of Arkansas, to remove or remedy the same: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of the law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

SEC. 4. That any bridge authorized to be constructed under this act be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the said bridge, and a map of the location, giving, for the space of one-half mile below the proposed location, the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; but should any change be made in the plan of said bridge during the progress of construction such change shall be subject to the approval of the Secretary of War.

SEC. 5. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in the said structure or its entire removal at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest so requires, is also expressly reserved.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof.

Approved, June 10, 1890.

AN ACT directing the issue of a duplicate of a lost check, drawn by O. M. Carter, lieutenant United States Engineer Corps, in favor of Charles C. Ely.

Whereas, It appears that O. M. Carter, lieutenant Engineer Corps, United States Army, did, on the third day of July, eighteen hundred and eighty-nine, issue a check numbered one hundred and thirty-nine thousand one hundred and sixty-four, upon the Assistant Treasurer of the United States, at New York, in favor of Charles C. Ely, for the sum of three thousand nine hundred and twenty-nine dollars and ninety-five cents, in payment of contract work done at Brunswick, Georgia, which check is alleged to have been lost in transmission through the United States mails by Benjamin D. Greene, of Philadelphia, Pennsylvania, to whom it had been assigned; and;

Whereas, The provisions of the act of February sixteenth, eighteen hundred and eighty-five, amending section thirty-six hundred and forty-six, Revised Statutes of the United States, authorizing United States disbursing officers and agents to issue duplicates of lost checks apply only to checks drawn for two thousand five hundred dollars or less; therefore,

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That said Lieutenant O. M. Carter be, and he is hereby, instructed to issue a duplicate of said original check under such regulations in regard to its issue and payment as have been prescribed by the Secretary of the Treasury for the issue of duplicate checks under the provisions of section thirty-six hundred and forty-six, Revised Statutes of the United States.

Approved, June 13, 1890.

AN ACT making appropriations for the support of the Army for the fiscal year ending June thirtieth, eighteen hundred and ninety-one, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and they are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, for the support of the Army for the year ending June thirtieth, eighteen hundred and ninety-one.

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MISCELLANEOUS.

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For additional pay to officer in charge of public buildings, and grounds, in Washington, District of Columbia, one thousand dollars.

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ENGINEER DEPARTMENT.

Engineer depot at Willets Point, New York: Incidental expenses of the depot, including fuel, chemicals, stationery, extra-duty pay to soldiers employed for periods of not less than ten days as artificers on work in addition to and not strictly in line of, their military duties, such as carpenters, blacksmiths draughtsmen, printers, lithographers, photographers, engine-drivers, teamsters, repairs of and for materials to repair public buildings, machinery and unforeseen expenses, five thousand dollars: *Provided*, That the appropriation of eight thousand dollars for an engineer museum at Willets Point, in act of March second, eighteen hundred and eighty-nine, be, and the same is hereby, continued in force for one year.

For purchase of materials for the instruction of engineer troops at Willets Point in their special duties of sappers and miners, for land and submarine mines, and pontoneers, torpedo drill and signaling, one thousand five hundred dollars.

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Approved, June 13, 1890.

AN ACT to prevent desertions from the Army, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after the first day of July, eighteen hundred and ninety, there shall be retained from the pay of each enlisted man of the Army the sum of four dollars per month of his monthly pay for the first year of his enlistment, which said sum shall not be paid him until his discharge from the service, and shall be forfeited unless he serves honestly and faithfully to the date of discharge: *Provided*, That

the Secretary of War shall determine what misconduct shall constitute a failure to render honest and faithful service within the meaning of this act; but no soldier who has deserted at any time during the term of an enlistment shall be deemed to have served such term honestly and faithfully: *Provided*, *also*, That the sums retained from the monthly pay of enlisted men, in accordance with section one of this act and sections twelve hundred and eighty-one and twelve hundred and eighty-two of the Revised Statutes, shall be treated as deposits, upon which interest shall be paid as provided in sections thirteen hundred and five, thirteen hundred and six, thirteen hundred and seven, and thirteen hundred and eight of the Revised Statutes, the said sums to bear interest from the end of the year of the soldier's enlistment in which they shall have accrued.

SEC. 2. That enlistments shall continue to be made for five years, as now provided by law: *Provided*, That at the end of three years from the date of his enlistment every soldier whose antecedent service has been faithful shall be entitled to receive a furlough for three months, and that in time of peace he shall at the end of such furlough be entitled to receive his discharge upon his own application: *Provided further*, That soldiers discharged under the provisions of this section shall not be entitled to the allowances provided in section twelve hundred and ninety of the Revised Statutes.

SEC. 3. That United States marshals and their deputies, sheriffs and their deputies, constables, and police officers of towns and cities are hereby authorized to apprehend, arrest, and receive the surrender of any deserter from the Army for the purpose of delivering him to any person in the military service authorized to receive him.

SEC. 4. That in time of peace the President may, in his discretion and under such rules and upon such conditions as he shall prescribe, permit any enlisted man to purchase his discharge from the Army. The purchase money to be paid under this section shall be paid to a paymaster of the Army and be deposited in the Treasury to the credit of one or more of the current appropriations for the support of the Army, to be indicated by the Secretary of War, and be available for the payment of expenses incurred during the fiscal year in which the discharge is made.

SEC. 5. That the Army ration now provided by law shall be increased by the addition thereto of one pound of vegetables, the proportion to be fixed by the Secretary of War.

Approved, June 16, 1890.

AN ACT authorizing and directing the Secretary of War to establish new harbor-lines in Portage Lake, Houghton County, Michigan.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War is hereby authorized and directed as speedily as the same can be done, to establish new harbor-lines in Portage Lake, Houghton County, Michigan, and that on each side of said Portage Lake between the shore and its corresponding harbor-line established as aforesaid, riparian owners may place and discharge, behind substantial bulkheads previously constructed along said harbor-lines, where such discharge may be made, the refuse, debris, tailings, or product of stamp mills.

SEC. 2. That all laws, and parts of laws in conflict with this act, are repealed. This act shall be in force from its passage.

Approved, June 20, 1890.

AN ACT to authorize the President of the United States to cause certain lands heretofore withdrawn from market for reservoir purposes to be restored to the public domain subject to entry under the homestead law with certain restrictions.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is hereby restored to the public domain all the lands described in certain proclamations of the President of the United States, dated March twenty-second, eighteen hundred and eighty, Executive Document Numbered Eight hundred and fifty-nine; also, April fifth, eighteen hundred and eighty-one, Executive Document Numbered Eight hundred and sixty-eight; also, February twentieth, eighteen hundred and eighty-two, Executive Document Numbered Eight hundred and seventy-four, withdrawing and withholding certain lands from market or entry and reserving the same to aid in the construction of certain reservoirs to be built at the head-waters of the Mississippi and Saint Croix Rivers, in the States of Minnesota and Wisconsin, and of the Chippewa and Wisconsin Rivers, in the State of Wisconsin; and that these lands, when so restored, shall be subject to homestead entry, only.

SEC. 2. That in all cases where any of the lands restored to the public domain by the first section of this act have heretofore been sold or disposed of by the proper officers of the United States under color of the public land laws, and the consideration received

therefor is still retained by the Government, the title of the purchasers may be confirmed, if in the opinion of the Secretary of the Interior justice requires it; but all the lands by said first section restored shall at all times remain subject to the right of the United States to construct and maintain dams for the purpose of creating reservoirs in aid of navigation; and no claim or right to compensation shall accrue from the overflowing of said lands on account of the construction and maintenance of such dams and reservoirs.

SEC. 3. That no rights of any kind shall attach by reason of settlement or squatting upon any of the lands hereinbefore described before the day on which such lands shall be subject to homestead entry at the several land offices, and until said lands are opened for settlement no person shall enter upon and occupy the same, and any person violating this provision shall never be permitted to enter any of said lands or acquire any title thereto. This act shall take effect six months after its approval by the President of the United States.

Approved, June 20, 1890.

AN ACT constituting Irondequoit Bay, New York, a navigable water of the United States for certain purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Irondequoit Bay, New York, shall, for the purpose of applying the provisions of title fifty-two of the Revised Statutes, relating to steam-vessels navigating thereon, be declared a navigable water of the United States; and steam-vessels navigated thereon, and carrying passengers, shall be inspected under the provisions of section forty-four hundred and twenty-six of the title referred to, and subject to the penalties provided therein for a failure to comply therewith.

Approved, June 25, 1890.

AN ACT granting pensions to soldiers and sailors who are incapacitated for the performance of manual labor, and providing for pensions to widows, minor children, and dependent parents.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in considering the pension claims of dependent parents, the fact of the soldier's death by reason of any wound, injury, casualty, or disease which, under the conditions and limitations of existing laws, would have entitled him to an invalid pension, and the fact that the soldier left no widow or minor children having been shown as required by law, it shall be necessary only to show by competent and sufficient evidence that such parent or parents are without other present means of support than their own manual labor or the contributions of others not legally bound for their support: *Provided*, That all pensions allowed to dependent parents under this act shall commence from the date of the filing of the application hereunder and shall continue no longer than the existence of the dependence.

SEC. 2. That all persons who served ninety days or more in the military or naval service of the United States during the late war of the rebellion and who have been honorably discharged therefrom, and who are now or who may hereafter be suffering from a mental or physical disability of a permanent character, not the result of their own vicious habits, which incapacitates them from the performance of manual labor in such a degree as to render them unable to earn a support, shall, upon making due proof of the fact according to such rules and regulations as the Secretary of the Interior may provide, be placed upon the list of invalid pensioners of the United States, and be entitled to receive a pension not exceeding twelve dollars per month, and not less than six dollars per month, proportioned to the degree of inability to earn a support; and such pension shall commence from the date of the filing of the application in the Pension Office, after the passage of this act upon proof that the disability then existed, and shall continue during the existence of the same: *Provided*, That persons who are now receiving pensions under existing laws, or whose claims are pending in the Pension Office, may, by application to the Commissioner of Pensions, in such form as he may prescribe, showing themselves entitled thereto, receive the benefits of this act; and nothing herein contained shall be so construed as to prevent any pensioner thereunder from prosecuting his claim and receiving his pension under any other general or special act: *Provided, however*, That no person shall receive more than one pension for the same period: *And provided further*, That rank in the service shall not be considered in applications filed under this act.

SEC. 3. That if any officer or enlisted man who served ninety days or more in the Army or Navy of the United States during the late war of the rebellion, and who was honorably discharged has died, or shall hereafter die, leaving a widow without other means of support than her daily labor, or minor children under the age of sixteen years,

such widow shall, upon due proof of her husband's death, without proving his death to be the result of his army service, be placed on the pension-roll from the date of the application therefor under this act, at the rate of eight dollars per month during her widowhood, and shall also be paid two dollars per month for each child of such officer or enlisted man under sixteen years of age, and in case of the death or remarriage of the widow, leaving a child or children of such officer or enlisted man under the age of sixteen years, such pension shall be paid such child or children until the age of sixteen: *Provided*, That in case a minor child is insane, idiotic, or otherwise permanently helpless, the pension shall continue during the life of said child, or during the period of such disability, and this proviso shall apply to all pensions heretofore granted or hereafter to be granted under this or any former statute, and such pensions shall commence from the date of application therefor after the passage of this act: *And provided further*, That said widow shall have married said soldier prior to the passage of this act.

SEC. 4. That no agent, attorney, or other person engaged in preparing, presenting, or prosecuting any claim under the provisions of this act shall, directly or indirectly, contract for, demand, receive, or retain for such services in preparing, presenting, or prosecuting such claim a sum greater than ten dollars, which sum shall be payable only upon the order of the Commissioner of Pensions, by the pension agent making payment of the pension allowed, and any person who shall violate any of the provisions of this section, or who shall wrongfully withhold from a pensioner or claimant the whole or any part of a pension or claim allowed or due such pensioner or claimant under this act, shall be deemed guilty of a misdemeanor, and upon conviction thereof shall, for each and every such offence, be fined not exceeding five hundred dollars, or be imprisoned at hard labor not exceeding two years, or both, in the discretion of the court.

Approved, June 27, 1890.

AN ACT to amend an act entitled "An act authorizing the construction of a bridge over the Missouri River at or near Kansas City, Kansas, and not over ten miles above the Hannibal and Saint Joseph Railway bridge at Kansas City, Missouri," approved March first, eighteen hundred and eighty-nine.

Be in enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for commencement and completion of the bridge authorized by said act as provided in section six thereof be, and is hereby, each extended one year from the passage of this act.

SEC. 2. That section three shall be amended by striking out the words "fifty-two" and inserting the word "fifty," so it shall read as follows:

"SEC. 3. That the said bridge shall be made with unbroken and continuous spans: the spans thereof shall not be less than four hundred feet in length in the clear, and the main span shall be over the main channel of the river. The lowest part of the superstructure of said bridge shall be at least fifty feet above extreme high-water mark, as understood at the point of location," and this bridge shall be at right angles to, and its piers parallel with, the current of the river: *Provided*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

Approved, June 28, 1890.

AN ACT authorizing the erection of a hotel upon the Government reservation at Fortress Monroe,

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized to grant permission to J. C. Asbury to build a hotel upon the lands of the United States at Fortress Monroe, Virginia, upon such site and with such plans and dimensions as may be approved by the Secretary of War: *Provided*, That the State of Virginia by its general assembly and governor, shall, by proper legal enactment, give the consent of said State to the erection of such hotel, and that the building or buildings erected shall be moved at the expense of the owner or owners whenever the Secretary of War shall direct, and no claim for damages by reason of such removal shall be made upon the Government of the United States: *And provided further*, That the building so erected shall be subject to State and national taxation as other property. *And provided further*, That the privilege herein granted shall become null and void unless said hotel shall be completed within two years after the passage of this act.

Approved, July 2, 1890.

AN ACT to authorize the County of Pulaski, in the State of Georgia, to maintain a high wagon and foot bridge across the Ocmulgee River at or near Hawkinsville in the State of Georgia.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the county of Pulaski, in the State of Georgia, be, and the same is hereby, authorized to maintain a free wagon and foot bridge across the Ocmulgee River at or near Hawkinsville, in said county and State.

SEC. 2. That the bridge authorized by this act shall be a high bridge of unbroken and continuous spans, and its lower chord shall not be of less elevation than fifty-three feet above ordinary low-water-mark, as understood at the point of location. That any bridge constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said county shall submit to the Secretary of War, for his examination and approval, the design and drawings of the bridge, piers, and approaches, and a map of the location, giving, for the space of at least one-half mile above and one half mile below the proposed location, the topography of the banks of the river, the shore-lines at high and low water, and the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, and the location of other bridge or bridges, wharves, landings, or ferries, and, shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built; and after such approval by the Secretary of War the approved plans and designs for the bridge shall not be deviated from or added to, either during the construction or after the completion of the bridge, until the proposed change shall have been submitted to the Secretary of War and received his approval; and the said bridge shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said bridge; and for the safety of vessels passing at night there shall be displayed on said bridge, from sunset to sunrise, such lights or other signals as may be prescribed by the Light-House Board; and if at any time the navigation of said river shall in any manner be obstructed or impaired by the bridge authorized by this act to be constructed, the Secretary of War shall have authority, and it shall be his duty, to require said county to alter and change the said bridge, at its own expense, in such manner as may be proper to secure free and complete navigation; and if, upon reasonable notice to said county to make such change or improvements, the said county fails to do so, the Secretary of War shall have authority to make the same, and all the rights conferred by this act shall be forfeited, and Congress shall have power to do any and all things necessary to secure the free navigation of the river; and if said bridge shall not be commenced within one year and finished within two years from the passage of this act the rights and privileges granted shall be null and void: *Provided, also*, That nothing in this act shall be so construed so as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operations of the same.

SEC. 3. That said county be, and the same is hereby, authorized with the approval of the Secretary of War, to so alter, change, and repair the bridge now owned and operated by said county across the Ocmulgee River at Hawkinsville as to make it conform to the provisions of this act.

SEC. 4. That the right to alter, amend, or repeal this act is hereby expressly reserved.

Approved, July 3, 1890.

AN ACT making appropriations for the legislative, executive, and judicial expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and ninety-one, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, in full compensation for the service of the fiscal year ending June thirtieth, eighteen hundred and ninety-one, for the objects hereinafter expressed, namely:

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WAR DEPARTMENT.

* * * * * * *

IN THE OFFICE OF THE CHIEF OF ENGINEERS: Chief clerk, at two thousand dollars; four clerks of class four; two clerks of class three; three clerks of class two; three clerks of class one; one clerk, at one thousand dollars; one assistant messenger; and two laborers; in all, twenty-three thousand two hundred and forty dollars.

And the services of skilled draughtsmen, civil engineers, and such other services as the Secretary of War may deem necessary may be employed in the office of the Chief of Engineers to carry into effect the various appropriations for rivers and harbors, fortifications, and surveys for military defenses, to be paid from such appropriations: *Provided*, That the expenditures on this account for the fiscal year ending June thirtieth, eighteen hundred and ninety-one, shall not exceed sixty thousand dollars; and that the Secretary of War shall each year, in the annual estimates, report to Congress the number of persons so employed and the amount paid to each.

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PUBLIC BUILDINGS AND GROUNDS.

OFFICE OF PUBLIC BUILDINGS AND GROUNDS. For one clerk, one thousand six hundred dollars; one messenger; one public gardener, one thousand eight hundred dollars; in all, four thousand two hundred and forty dollars.

For overseers, draughtsman, foremen, mechanics, gardeners, and laborers employed in the public grounds, thirty thousand dollars.

For day watchman in Franklin Square, six hundred and sixty dollars.

For day watchman in Lafayette Square, six hundred and sixty dollars.

For two day watchmen in Smithsonian Grounds, at six hundred and sixty dollars each, one thousand three hundred and twenty dollars.

For two night watchmen in Smithsonian Grounds, at seven hundred and twenty dollars each, one thousand four hundred and forty dollars.

For one day watchman at Judiciary Square, and one at Lincoln Square and adjacent reservations, at six hundred and sixty dollars each, one thousand three hundred and twenty dollars.

For one day watchman at Iowa Circle; one at Thomas Circle and neighboring reservations; one at Rawlins Square and Washington Circle; one at Dupont Circle and neighboring reservations; one at McPherson and Farragut Square; one at Stanton Square and neigboring reservations; two at Henry Square, Seaton Square, and reservations east of Botanic Garden; one at Mount Vernon Square and adjacent reservations; one for the green-house and nursery; one at the grounds south of Executive Mansion; eleven in all, at six hundred and sixty dollars each, seven thousand two hundred and sixty dollars.

For one night watchman at Henry Square, Seaton Square, and reservations east of Botanic Garden, seven hundred and twenty dollars.

For contingent and incidental expenses, five hundred dollars.

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Approved July 11, 1890.

AN ACT granting to the Jacksonville, Saint Augustine and Halifax River Railway Company a right of way across the United States Military reservation at Saint Augustine, Florida.

Be it enacted by the Senate the House of Representatives of the United States of America in Congress assembled, That the Jacksonville, Saint Augustine and Halifax River Railway Company, a corporation duly organized and existing under the laws of the State of Florida, be, and is hereby, granted a right of way across the prolongation of "the lines" or ditch on the United States military reservation at Saint Augustine, Florida, for the construction, maintenance, and use thereon of one or more tracks and sidings, as may be approved by the Secretary of War: *Provided*, That the said right of way shall not exceed one hundred feet in width, and shall be subject to such change, revocation, or removal as may be prescribed by the Secretary of War, at the expense of the railway company.

SEC. 2. That the said company shall provide and keep clear a sufficient channel at the proper grade for the flow into and out of the ditch in "the lines," and shall, upon request by the Secretary of War, provide a grade crossing for teams and tramcars across its tracks in the prolongation of "the lines."

SEC. 3. That the work hereby authorized and directed shall be done to the satisfaction of the Secretary of War.

SEC. 4. That if the right hereby conferred shall not be exercised and the road built within two years next after the passage of this act all the rights and authority hereby granted shall absolutely cease and determine.

Approved, July 11, 1890.

AN ACT to incorporate the North River Bridge Company and to authorize the construction of a bridge and approaches at New York City across the Hudson River, to regulate commerce in and over such bridge between the States of New York and New Jersey, and to establish such bridge a military and post road.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That authorization is hereby given to Jordan L. Mott, John King McLanihan, James Andrews, Thomas F. Ryan, Garrett A. Hobart, F. W. Roebling, Charles J. Canda, Edward F. C. Young, Henry Flad, Gustav Lindenthal, A. G. Dickinson, John H. Miller, William Brookfield, Samuel Rea, William F. Shunk, Philip E. Chapin, and their associates, as a corporation as hereinafter provided, to locate, build, maintain, equip, and operate a bridge, proper approaches thereto and terminals, appurtenances and works connected therewith, across the Hudson River in and between the city of New York, in the State of New York, and the State of New Jersey, and to lay tracks thereon for the connection of the railroads on either side of said river, in order to facilitate interstate commerce in the transportation of persons and property, and for vehicle, pedestrian, postal, military, and other purposes: *Provided*, That said bridge shall have not less than six railroad tracks with a capacity for four additional tracks for future enlargement, and shall be constructed with a single span over the entire river between the towers, located between the shore and the established pier head lines in either State, and at an elevation above the river not less than that of the existing Brooklyn suspension bridge, over the East River, and which elevation may be increased by the Secretary of War as hereinafter provided, and that no pier or other obstruction to navigation either of a temporary or permanent churacter, shall be constructed in the river between said towers.

SEC. 2. That the construction of said bridge shall be commenced within three years after the passage of this act, and shall be completed within ten years after the commencement of construction. But that the Secretary of War is hereby authorized to extend the time for the commencement of construction for two additional years upon cause shown by the company, and provided that the Secretary of War shall deem such cause sufficient and satisfactory; and that if the company fail to commence the construction of said bridge within the time so extended this act shall be null and void. And the company at least three months previous to commencing the erection of said bridge shall submit to the Secretary of War a plan of the bridge, with a detailed map of the river at the proposed site of the bridge, and for the distance of one-half of a mile above and below the site, with such other information as the Secretary of War may require for a full and satisfactory understanding of the subject. And the Secretary of War may upon receiving said plans and map and other information, order a hearing before a board of engineers, appointed by him for taking testimony of persons interested in railroads and navigation, relative to the clear height of the superstructure above ordinary high water. Such clear height shall not be less than that named in section one of this act, and the Secretary of War may thereupon order such additional clear height as he shall deem necessary for the security of navigation. And he is hereby authorized and directed upon being satisfied that a bridge built on such plan and at said locality will conform to the conditions of this act to notify the said company that he approves the plans therefor; whereupon said company may proceed to the erection of said bridge. But until the Secretary of War approve the plan and location of said bridge the erection of the same shall not be commenced; and should any change be made in the plan of the bridge during the progress of the work thereon, such change shall likewise be subject to the approval of the Secretary of War.

SEC. 3. That the bridge, with its approaches and railroad thereover, constructed under the provisions of this act shall be a lawful structure, and a military and post road, but no toll charges shall be made for the transmission over the same of the mails of the United States, or for the right of way for United States postal telegraph purposes.

SEC. 4. That for the purpose of carrying into effect the objects stated in this act, the persons named in the first section hereof, and their associates, are hereby constituted and created a body corporate in law, to be known as the North River Bridge Company, and by that name, style, and title shall have perpetual succession; may sue and be sued, implead and be impleaded, complain and defend, in all courts of law and equity, of record and otherwise; may make and have a common seal, and shall have and possess all the rights, powers, franchises, and privileges incident to or usually possessed by such companies. It may receive, purchase, and also acquire by lawful appropriation and condemnation upon making proper compensation therefor, to be ascertained according to the laws of the State within which the same is located, real and personal property and rights of property, and may mortgage, encumber, charge, pledge, grant, lease, sell, assign, and convey the same. And to aid in the construction of said bridge and approaches thereto, and railroad terminals, appurtenances, and works connected therewith, and to carry out the purposes of this act, the said North River Bridge Company is hereby authorized to issue its bonds and secure the same by mortgage on its property and rights

of property of all kinds and descriptions, and its franchise to be a corporation. And generally and specially, for the fully carrying out of the purposes and intentions of this act, the said North River Bridge Company, and its successors, shall have and possess all such rights and powers to enter upon lands, and for the purchase, acquisition, condemnation, appropriation, occupation, possession, and use of real estate and other property, and for the location, construction, operation, and maintenance of said bridge with its approaches, terminals, and appurtenances as are possessed by railroad or bridge companies in the States of New York and New Jersey, respectively. That all persons, railroad and telegraph companies, respectively, desiring to use said bridge shall have and be entitled to equal rights and privileges in the passage over and the use of the same, and the approaches thereto, for a resonable compensation, to be approved by the Interstate Commerce Commission as hereinafter determined, and to be paid to the North River Bridge Company, which is hereby duly empowered to collect the same. And sufficient trackage and terminal facilities shall be provided for all railroads desiring to use said bridge and appurtenances. In case any litigation arises out of the construction, use, or operation of said bridge or approaches thereto and railroad thereon, or for the condemnation or the appropriation of property in connection therewith under this act, the cause so arising shall be heard an tried before the circuit court of the United States for the judicial district in which the bridge or one of the approaches is located. Applications for condemnation or appropriation of property shall be made in the circuit court of the United States for the district in which such property is situated upon the petition of said company, and the hearing and trial of all other proceedings thereon shall conform as nearly as may be to the practice in the courts of the State in which such district is situated in the case of condemnation or appropriation of property for railroads.

SEC. 5. That the Interstate Commerce Commission is hereby authorized to require the said North River Bridge Company, in addition to such reports as it may lawfully require of railroad companies, a statement certified to by the president of said North River Bridge Company of the actual cash expenditure for all property acquired and for the cost of construction of all structures and appurtenances, for equipment and for other proper and legitimate expenses incurred under this act; said statement shall be made on the completion of all the work and before the said North River Bridge Company shall collect tolls from the connecting railroad companies. The Interstate Commerce Commission shall be authorized to employ, at the expense of said North River Bridge Company, such expert accountants as it may appoint and direct to examine the accounts of said North River Bridge Company for the purpose of verifying the said actual cash expenditures under this act. And the said ascertained cash expenditures shall form the basis on which the Interstate Commerce Commission shall approve the toll charges to be paid by the connecting railroad companies to said North River Bridge Company for the use of said bridge, approaches, tracks, and terminals in such manner that whenever the net revenue derived from said toll charges, after paying all expenses for the proper and safe operation aud maintenance of its property, and after paying all taxes, and after deducting five per centum of the gross revenue for the sinking fund, to be applied to the liquidation of any indebtedness, shall exceed ten per centum on the above-specified cash expenditure, the Interstate Commerce Commission may order a reduction of toll charges: *Provided*, That said reduction shall not be ordered oftener than once in three years: *Provided further*, That nothing contained in this section shall be construed as establishing contract rights between the United States and said North River Bridge Company as to the rate of toll authorized to be collected, but this section shall be subject to amendment or repeal as is provided may be in relation to every section of this act.

SEC. 6. That the government and direction of said company shall be vested in a board of seven directors, who shall be stockholders of record, and who shall hold their office for one year, and until their successors are duly elected and qualified. The said directors, five of whom shall be a quorum, shall elect one of their number president; they shall also appoint a secretary and treasurer. The directors of said company shall have power to make such prudential by-laws as they shall deem proper for the management and disposition of the stock, property, and business affairs of said company, not contrary to the laws of the United States, and prescribing the duties of officers, artificers and servants that may be employed, for filling vacancies, and for carrying on all business within the objects and purposes of said company. There shall be an annual meeting of the stockholders for choice of directors, to be held at such time and place, under such conditions and upon such notice as the by-laws may prescribe; and such directors shall annually make a report of their doings and of the business of the company to the stockholders, a copy of which, sworn to and signed by the president of the company, shall be transmitted to the Interstate Commerce Commission. Failure to elect directors on the day fixed by said by-laws shall not be deemed to dissolve said company, but such election may be held on any day appointed thereafter by the directors, first giving thirty days' notice thereof, in manner provided in said by-laws. The capital stock of

said company shall consist of not less than ten thousand shares of one hundred dollars each, which shall in all respects be deemed personal property, and shall be transferable in such manner as the by-laws of said company shall provide; but no share shall be transferable until all calls thereon shall have been fully paid in, and it shall not be lawful for said company to use any of its funds in the purchase of any stock in its own or any other corporation. The amount of such capital stock may be increased upon the vote of two-thirds of such stock of said company at any time outstanding.

SEC. 7. That the real and personal property of the company shall be subject to taxation for State, county, and municipal purposes in the State where the same is located, but at no higher rate than other real and personal property in the State.

SEC. 8. That the said North River Bridge Company shall maintain on the bridge, at its own expense, from sunset to sunrise, such lights or signals as the United States Light-House Board shall prescribe.

SEC. 9. That nothing in this act shall be held or construed to in any manner involve the United States Government in any pecuniary obligations whatever, other than the payment of tolls over said bridge and approaches for troops and munitions of war, for which no higher charge per mile shall be made than the rate paid to railroads connecting with said bridge; but Congress hereby reserves the right to alter, amend, or repeal this act as the contingencies of commerce or the public good may require, and said company shall further be subject to the provisions of the interstate-commerce laws, and any amendments and supplements thereof.

Approved, July 11, 1890.

AN ACT to authorize the Leavenworth and Platte County Bridge Company to substitute a pivot draw bridge over the Missouri River in place of a pontoon bridge.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Leavenworth and Platte County Bridge Company be authorized to substitute for the pontoon bridge across the Missouri River, provided for in an act approved February twenty-five, eighteen hundred and eighty-nine, entitled "An act to authorize the construction of a bridge across the Missouri River, between the city of Leavenworth, in the State of Kansas and Platte county, in the State of Missouri," a pivot draw bridge and in case of the substitution of such pivot draw bridge the same shall not be built or commenced until the plan and specification for its construction have been submitted to the Secretary of War for his approval, nor until he shall approve the plan and location of said bridge; and if any change be made in the plan of construction of said bridge at any time such change shall be subject to the approval of the Secretary of War; and any change in the construction, or any alteration of said bridge that may be directed at any time by Congress or the Secretary of War, shall be made at the cost and expense of the owners thereof: *Provided*, That said Leavenworth and Platte County Bridge Company shall at its own expense, build and maintain, under direction and supervision of the Secretary of War, such wing-dams and booms or other works necessary to maintain the channel within the draw span or spans of said bridge.

SEC. 2. That this act shall be in force from and after its approval.

Approved, July 25, 1890.

AN ACT to allow the erection of a bridge across the Iowa River between the mouth of said river and the town of Wapello, in Louisa County, Iowa.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That, subject to the laws of the State of Iowa, the supervisors of Louisa County, in said State, may erect and maintain a wagon and foot passenger bridge, across and over the Iowa River, between the mouth of said river and the town of Wapello, in Louisa County, in said State; and in said bridge no draw shall be required.

SEC. 2. The bridge authorized to be constructed by this act shall be located and built under and subject to such regulations as may be approved by the Secretary of War; and there shall be submitted to said Secretary, for his examination, a design and drawings of the bridge, piers, approaches, and accessory works, and a map of the location; and until said plan is approved by the Secretary of War the construction of said bridge shall not be commenced. No changes or alterations in the plans of said bridge as approved by the Secretary of War, shall be made during the construction of the same, or after its completion, unless said changes or alterations are authorized by said Secretary; and all such alterations or changes required by him shall be made at the expense of the supervisors of said county. It is further provided that whenever the Secretary of War shall so re-

quire the entire structure shall be removed at the expense of the supervisors of said Louisa County, or the owners of said bridge.

SEC. 3. That the bridge constructed, maintained, and operated under this act and according to its limitations shall be a legal structure, and shall be recognized and known as a post route, upon which no higher charges shall be made for the transportation over the same of the mails, the troops, and the munitions of war of the United States than is charged to other persons for crossing said bridge; and the United States shall have the right of way for postal, telegraph, and telephone purposes over said bridge. And all telegraph and telephone companies shall have equal rights and privileges in constructing and maintaining their lines over said bridge: *Provided*, That all tolls charged for crossing over said bridge shall be subject to the approval of the Secretary of War.

SEC. 4. That the right to alter, amend, or repeal this act is expressly reserved whenever Congress shall decide that the public interests so require; and if actual construction of the bridge herein authorized shall not be commenced within two years and completed within four years from the date of the approval of this act, the provisions of the same are hereby declared to be null and void.

Approved, July 30, 1890.

AN ACT making appropriations to provide for the expenses of the government of the District of Columbia for the fiscal year ending June thirtieth, eighteen hundred and ninety-one, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the half of the following sums named, respectively, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, and the other half out of the revenues of the District of Columbia, for the purposes following, being for the expenses of the government of the District of Columbia for the fiscal year ending June thirtieth, eighteen hundred and ninety-one, namely:

GENERAL EXPENSES.

SALARIES AND CONTINGENT EXPENSES.

FOR EXECUTIVE OFFICE: For * * * one Engineer Commissioner, four hundred and twenty-four dollars (to make salary five thousand dollars).

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WASHINGTON AQUEDUCT.

For engineering, maintenance, and general repairs, twenty thousand dollars.

For the purchase of five acres of land near the distributing reservoir, four thousand dollars.

For the cost of a survey by a sworn surveyor, for removing the cattle-pens, clearing up and fencing the ground, for the works for controlling the drainage, and for other necessary improvements, one thousand five hundred dollars.

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TELEGRAPH AND TELEPHONE SERVICE.

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The President of the United States is hereby authorized to appoint a board consisting of three persons, one of whom shall be an Army engineer, skilled in electrical matters, one a civil engineer, of known skill and experience in Municipal engineering, And one an expert electrician of high repute: *Provided*, That not more than one member shall be a resident of the District of Columbia; and no member shall be in the employ of any electrical Company, or shall have any interest in the business or securities of such company, or be interested in any patent for any form of conduit or subway, or device pertaining thereto. The said board shall consider the location, arrangement and operation of electric wires in the District of Columbia, whether used, or to be used, for electric lighting, transmission of power, telegraphy, telephony, or signalling, with a view to securing, as soon as practicable, the construction of a safe and convenient system of conduits or subways, the placing therein of all necessary electric wires along the streets, avenues and other public spaces, and the removal of all unused overhead wires and their supports. To this end, the board, will, as soon as practicable, and not later than

December first, eighteen hundred and ninety-one, report to the President, who shall submit the same to the first session of the Fifty-second Congress, as follows:

First. Recommendations for a complete system of conduits or subways, with all suitable branches, connections, and appurtenances for the safe and efficient operation therein of the necessary cables and conductors; such recommendations shall be accompanied by maps, detailed drawings and estimates of cost.

Second. Opinion as to whether the conduits or subways should be built, owned and operated by private corporations or individuals, subject to public control, or constructed and maintained by public authority, and leased to companies or individuals. If the latter, recommendation will be made as to the terms and conditions upon which such leases should be executed.

Third. Also recommendations concerning the construction, location, operation, and maintenance, of under-ground cables and conductors carrying currents of different intensities, with a view to promote the public safety, and to secure the most convenient and efficient use of such cables and conductors, and the appliances connected therewith.

Fourth. Recommendations as to the restrictions, if any, which should be imposed by law, upon the character and intensity of electric currents conveyed by conductors situated over or under the public streets, avenues, and spaces, and used for electric lighting, transmission of power, telegraphy, telephony, or signalling.

Fifth. Recommendations respecting the regulation of the arrangement and use of authorized overhead wires.

To meet the expenses of the said board there is hereby appropriated the sum of ten thousand dollars, or so much thereof as may be necessary: *Provided*, that the officer detailed from the Corps of Engineers shall not receive any salary except that due to his rank.

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Approved August 6, 1890.

AN ACT to authorize the construction of a bridge across the Savannah River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of the United States of America is hereby given to "The South Bound Railroad Company," a corporation incorporated by the laws of the State of Georgia and by the laws of the State of South Carolina, its successors and assigns, and such other persons as may be associated with it, to construct and maintain a bridge over the Savannah River at a point by it to be selected at or near "Sister's Ferry," in the County of Effingham.

SEC. 2. That the bridge shall be so constructed, by draw span or otherwise, that a free and unobstructed passage may be secured to all vessels and other water-craft navigating said river. That any bridge constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company shall submit to the Secretary of War, for his examination and approval, the design and drawings of the bridge, piers, and approaches, and a map of the location, giving, for the space of at least one mile above and one mile below the proposed location, the topography of the banks of the river, the shore-lines at high water and at low water, and the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream and the location of other bridge or bridges, wharves, landings, or ferries, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built, and after such approval by the Secretary of War the approved plans and designs for the bridge shall not be deviated from or added to either during the construction or after the completion of the bridge until the proposed change shall have been submitted to the Secretary of War and received his approval; and the said bridge shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said bridge, and if said bridge be built with a draw said draw shall be opened promptly upon reasonable signal for the passage of boats or other craft, and the said company or corporation shall maintain, at its own expense, from sunset until sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe; and if at any time the navigation of said river shall in any manner be obstructed or impaired by the bridge authorized by this act to be constructed the Secretary of War shall have authority, and it shall be his duty, to require said company to alter and change said bridge, at its own expense, in such manner as may be proper to secure free and complete navigation without impediment; and if upon reasonable notice to said company, its successors or assigns, to make such change or improvements, the said company fails to do so, the Secretary of War shall have authority to make the same, and all the rights conferred by

this act shall be forfeited upon said failure, and Congress shall have power to do any and all things necessary to secure the free navigation of said river: *Provided, also*, That nothing in this act shall be so constructed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operations of the same.

SEC. 3. That any bridge built under this act and subject to its limitations shall be a lawful structure and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and munitions of war of the United States, or passengers or freight over said bridge than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge, and they shall enjoy the rights and privileges of other post-roads of the United States. And equal privileges in the use of said bridge shall be granted to all telegraph companies, and the United States shall have the right of way across said bridge and its approaches for said postal telegraph purposes.

SEC. 4. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in said structure, or its removal, at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest requires it, is also expressly reserved.

SEC. 5. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years and completed within four yaars from the date hereof.

Approved, August 7, 1890.

AN ACT authorizing the construction of a bridge over the Tennessee River at or near Guntersville or Deposit, Alabama, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Tennessee and Coosa Railroad Company of Alabama, a corporation duly and legally incorporated under the laws of the State of Alabama, its successors or assigns, to construct and maintain a bridge over the Tennessee River at or near Guntersville or at or near Deposit, Alabama. Said bridge shall be constructed to provide for the passage of railway trains, and at the option of the persons by whom it may be built, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot passengers, for such reasonable rates of toll as may be approved from time to time by the Secretary of War.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States, or passengers or freight passing over said bridge, than the rate per mile paid for the transportation over the railroad or public highways leading to the said bridge; and it shall enjoy the rights and privileges of other post-roads in the United States. And equal privileges in the use of said bridge shall be granted to all companies upon such terms as may be agreed upon by the parties, and if they can not agree, then as the same shall be determined by the Secretary of War; and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes, and all telegraph and telephone companies shall have equal rights and privileges in constructing and maintaining their lines across said bridge.

SEC. 3. That the said bridge shall be constructed as a draw-bridge; the draw or pivot-pier shall be at such point in the channel of the river as the Secretary of War may direct, and the opening or passage-way of said draw-pier shall be so protected and arranged that water craft can be worked through it at any and all times; and the draw-span shall not be of less width, nor shall the lowest part of the same be of less elevation above high-water, than are the widest and highest of those authorized by Congress for any bridge over the Tennessee River, and the piers of said bridge shall be parallel with and the bridge itself at right angles to the current of the river: *Provided*, That in said bridge there shall be one span of not less than three hundred feet in the clear: *Provided, also*, That said draw shall be opened promptly upon reasonable signal for the passing of boats; and said company or corporation shall maintain, at its own expense, from sunset till sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe. No bridge shall be erected or maintained under the authority of this act which shall at any time substantially or materially obstruct the free navigation of said river; and if any bridge erected under such authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction; and all such alterations shall be made and all such obstructions be removed at the

expense of the owner or owners of said bridge; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the cause may be brought in the circuit court of the United States of the State of Alabama in whose jurisdiction any portion of said obstruction or bridge may be located: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

SEC. 4. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them desiring such use shall fail to agree upon the sum or sums to be paid and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War, upon a hearing of the allegations and proofs of the parties.

SEC. 5. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built. And if any change is required by the Secretary of War in the plan of said bridge, whilst the same is in process of construction, or after its completion, or if the entire removal of said bridge is required by him at any time, the cost of such change or removal shall be paid by the company owning or controlling said bridge.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years and completed within three years from the date of the approval of this act.

SEC. 7. That the right to alter, amend, or repeal this act is hereby expressely reserved.

Approved, August 15, 1890.

AN ACT to amend an act approved August sixth, eighteen hundred and eighty-eight, authorizing the construction of bridges by the Houston, Central Arkansas and Northern Railway Company.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act approved August sixth, eighteen hundred and eighty-eight, entitled "An Act authorizing the Houston, Central Arkansas and Northern Railway Company to construct and maintain bridges across Bayou Bartholomew and across Ouachita, Red, Little and Sabine Rivers in Louisiana," be and is hereby amended so that the time within which the actual construction of said bridges may be commenced is hereby extended for the period of one year from the date of the approval of this Act.

Approved, August 18, 1890.

AN ACT making appropriations for fortifications and other works of defense, for the armament thereof, for the procurement of heavy ordnance for trial and service, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the sums of money herein provided for be, and the same are hereby, appropriated, out of any moneys in the Treasury not otherwise appropriated, to be available until expended, namely:

PRESERVATION AND REPAIR OF FORTIFICATIONS: For the protection, preservation, and repair of fortifications for which there may be no special appropriations available, eighty thousand dollars.

For preparation of plans for fortifications, five thousand dollars.

For repair and preservation of Fort Marion, Florida, and for construction of sea-wall to preserve the site, fifteen thousand dollars.

For completing sea-wall at Governor's Island, New York Harbor, fifty thousand dollars.

TORPEDOES FOR HARBOR DEFENSE: For the purchase of submarine mines and necessary appliances to operate them for closing the channels leading to our principal seaports, one hundred thousand dollars.

For needful casemates and cable galleries to render it possible to operate submarine mines, one hundred thousand dollars.

For continuing torpedo experiments and for practical instruction of engineer troops in the details of the service, thirty thousand dollars.

* * * * * * *

For the following, to be expended under the direct supervision of the Board of Ordnance and Fortification, created by the fortification appropriation act approved September twenty-second, eighteen hundred and eighty-eight, and in the manner prescribed by said act, namely:

GUN AND MORTAR BATTERIES: For construction of gun and mortar batteries for defense of Boston Harbor, two hundred and thirty-five thousand dollars; New York, seven hundred and twenty-six thousand dollars; San Francisco, two hundred and sixty thousand dollars; in all, one million two hundred and twenty-one thousand dollars.

For the procurement of land, or right pertaining thereto, needed for the site, location, construction, or prosecution of works, for fortifications and coast defenses, five hundred thousand dollars, or so much thereof as may be necessary, and hereafter the Secretary of War may cause proceedings to be instituted, in the name of the United States, in any court having jurisdiction of such proceedings, for the acquirement, by condemnation, of any land, or right pertaining thereto, needed for the site, location, construction, or prosecution of works for fortifications and coast defenses, such proceedings to be prosecuted in accordance with the laws relating to suits for the condemnation of property of the States wherein the proceedings may be instituted: *Provided*, That when the owner of such land or rights pertaining thereto shall fix a price for the same, which, in the opinion of the Secretary of War, shall be reasonable, he may purchase the same at such price without further delay: *Provided further*, That the Secretary of War is hereby authorized to accept on behalf of the United States donations of lands or rights pertaining thereto required for the above-mentioned purposes: *And provided further*, That nothing herein contained shall be construed to authorize an expenditure, or to involve the Government in any contract or contracts for the future payment of money, in excess of the sums appropriated therefor.

* * * * * * *

That all material purchased under the foregoing provisions of this act shall be of American manufacture.

* * * * * * *

That the President is hereby authorized to appoint a board to consist of three officers of the Army, one of engineers, one of artillery, and one of ordnance, not below the rank of lieutenant-colonel, who shall inquire into the facilities for producing steel forgings for high-power guns at or near the Pacific coast; and in the vicinity of the Rock Island Arsenal, and in the vicinity of the Indianapolis Arsenal, and at some point on or near the Gulf coast, and the advisability of erecting gun factories for finishing and assembling high-power guns, to be mounted in fortifications, at the Benicia Arsenal, in California, or at the Rock Island Arsenal, or at the Indianapolis Arsenal, or at some point on or near the Gulf coast.

Said board shall also examine and report as to the capacity, cost of erection, and equipment of each of such gun factories.

For the payment of the necessary expenses of said board, three thousand dollars.

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Approved, August 18, 1890.

AN ACT to amend an act entitled "An act to authorize foot and carriage or railroad bridges across the Mississippi River at Saint Paul, in the State of Minnesota," approved July fifth, eighteen hundred and eighty-four

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section two of an act entitled "An act to authorize foot and carriage or railroad bridges across the Mississippi River at Saint Paul, in the State of Minnesota," approved July fifth, eighteen hundred and eighty-four, be amended so as to read as follows:

"SEC. 2. That any bridge or bridges built under the provisions of this act may, by direction of said common council, be built as a draw-bridge with a pivot or other form of draw, or with unbroken or continuous spans: *Provided*, That if said bridge or bridges shall be built with unbroken and continuous spans it shall give a clear head room of not

less than fifty-five feet above high-water mark, as the same shall be fixed and determined by the Secretary of War, over the main channel of said river, and the main span shall be over the main channel of the river and give a clear width of water-way of not not less than three hundred feet and the clear head room and clear width of water-way given by other spans shall be such as in the opinion of the Secretary of War will best serve the interests of navigation, and the piers of said bridge shall be parallel, as near as may be, with the current of said river: *And provided, also,* That if any bridge or bridges, built under this act, shall be constructed as a draw-bridge, the same shall be constructed as a pivot draw-bridge, with a draw or draws over the main channel or channels of the river at accessible and the best navigable point or points, and with spans giving for each draw required a clear width of water-way of not less than one hundred and sixty feet on each side of the central or pivot pier; and all spans shall give not less than ten feet clear head room above high-water mark, as determined by the Secretary of War, and the piers of said bridge or bridges shall be parallel, as near as may be, with the current of the river where said bridge or bridges may be erected: *And provided, also,* That said draw or draws shall be opened promptly upon reasonable signal for the passage of boats, vessels, or other water-craft: *Provided, however,* That no bridge or bridges shall be built under the provisions of this act except upon the condition that there also be built at the time of erection of the piers, or whenever the same be necessary, proper sheer-booms or other proper structures to safely guide boats, vessels, rafts, and other water-crafts through said spans and at the expense of the city of Saint Paul, or of the persons or corporation constructing, owning, or operating said bridge."

SEC. 2. That the right to alter, amend, or repeal this act, whenever in the opinion of Congress the public interests shall so require, is hereby expressly reserved.

Approved August 29, 1890.

AN ACT to authorize the construction of a bridge across the Mississippi River at some accessible point between the mouth of the Illinois and the mouth of the Missouri Rivers.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Saint Clair, Madison and Saint Louis Belt Railroad Company, a corporation organized under the laws of the State of Illinois, its successors, is hereby authorized to construct and maintain a bridge across the Mississippi River at such point as may be hereafter selected by said corporation, between the mouth of the Illinois River and the month of the Missouri River, as shall best promote the public convenience and welfare and the necessities of business and commerce. That said bridge shall be constructed to provide for the passage of railroad trains, and, at the option of the corporation by which it may be built, for the transit of foot passengers, animals, wagons, and vehicles of all kinds, for such reasonable rates of toll as may be approved from time to time by the Secretary of War.

SEC. 2. That such bridge shall be constructed and built without interference with the security and convenience of navigation of such river beyond what is necessary to carry into effect the rights and privileges hereby granted; and in order to secure that object the said corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving for the space of one mile above and one mile below the proposed location the topography of the banks of the river, the shore-lines at high and low water, the location of any other bridge or bridges, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be commenced or built; *Provided,* That if the said bridge shall be made with unbroken and continuous spans it shall have one channel span of not less than three hundred and fifty feet in length and of an elevation not less than fifty-five feet above high-water mark as understood at the point of location to the lowest part of the superstructure, and the clear head-room of other than channel spans may be less than fifty-five feet: *And provided, also,* That if said bridge shall be made with unbroken and continuous spans there shall, during the season of navigation, be posted in a conspicuous place on or near the bridge, the clear head-room under the channel span on that day, the figures expressing this height, to be readily visible to the naked eye from any point in the channel of the river for a stretch of four thousand feet, of which three thousand shall be above and one thousand shall be below the channel span of said bridge, and the piers of said bridge shall be parallel with the current of the river: *And provided, also,* That if any bridge built under this act shall be constructed as a draw-bridge, the same shall be constructed as a pivot draw-bridge with a draw at a point accessible and convenient for navigation, and with spans of not less than two hundred feet in length in the clear on each side of the central or pivot pier of the draw, and the next adjoining span or spans shall not be less than three

hundred and fifty feet in length, and the head-room under such spans shall not be less than ten feet above high water: *And provided, also*, That if any bridge built under this act shall be constructed as a draw-bridge the same shall be provided with such protection piers and guide piers as the Secretary of War shall require, and there shall be displayed at a point plainly visible to boats passing through the draw a record showing the stage of water and whether the river is rising or falling: *Provided also*, That said draw shall be opened promptly upon reasonable signal for the passage of boats, and said corporation shall maintain at its own expense from sunset to sunrise such lights or other signals on said bridge as the Light-House Board shall prescribe: *Provided, also*, That all railroad companies desiring the use of such bridge shall have and be entitled to equal rights and priviieges relative to the passage of railroad trains over the same and over the approaches thereto upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies or any one of them desiring such use shall fail to agree upon the sum or sums to be paid, and the rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

SEC. 3. That the Secretary of War is hereby authorized and directed upon receiving such plan and map and other information, and upon being satisfied that a bridge built upon such plan and with such accessory works and at such locality will conform to the prescribed conditions of this act, to notify the company that he approves the same; and upon receiving such notification the said company may proceed to the erection of said bridge, conforming strictly to the approved plan and location; and should any change be made in the plan of the bridge or said accessory works during the progress of the work thereon such change shall be subject likewise to the approval of the Secretary of War; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the case may be brought in the circuit court of the United States for the district in whose jurisdiction any portion of said obstruction or bridge may be located.

SEC. 4. That the said bridge, when built and constructed under this act and according to the terms and limitations thereof, shall be a lawful structure; and said bridge shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge; and said bridge shall enjoy the rights and privileges of other post-routes in the United States.

SEC. 5. That the United States shall have the right of way for such postal and telegraph lines across said bridge as the Government may construct or control, and all telegraph and telephone companies shall have equal rights and privileges in constructing and maintaining their lines over said bridge.

SEC. 6. That Congress shall have power at any time to alter, amend, or repeal this act whenever in its judgment the public interests so require; and all alterations of said bridge, or its entire removal, shall be made at the expense of the owners of or persons controlling such bridge: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provision of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

SEC. 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years and completed within four years from the date thereof.

Approved, August 29, 1890.

AN ACT to authorize the construction of a bridge across the Columbia River by the Oregon Railway Extensions Company.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Oregon Railway Extensions Company, a corporation existing under the laws of the State of Oregon, its successors, and assigns, be, and is hereby, authorized to construct and maintain, if in the opinion of the Secretary of War the same be a public necessity, a bridge across the Columbia River at a place suitable to commerce and not interfering with navigation, at a point at or near Vancouver, in the State of Washington, and to lay on or over said bridge a track or tracks for the more perfect connection of any railroad or railroads that are or shall be constructed to said river, on either or both sides thereof, at or opposite said point, under the limitations and conditions hereinafter provided; that said bridge shall not interfere with the free navigation of said river, and in case of any litigation arising from any obstruction or alleged obstruction to

the free navigation of said river, by reason of the construction of said bridge, the cause may be tried before the circuit court of the United States in and for any district in whose jurisdiction any portion of said obstruction or bridge may be. Said bridge shall be constructed to provide for the passage of railroad trains, and, at the option of the said company or corporation, its successors and assigns, for the safe and convenient passage of wagons and vehicles of all kinds, animals and foot-passengers, for such reasonable rates of toll as may be fixed from time to time by the Secretary of War.

SEC. 2. That said bridge shall be provided with two or more draw-openings, each having not less than two hundred feet clear channel-way, and in addition to said draw-openings one or more fixed channel-spans, each having not less than three hundred and fifty feet clear channel-way; and every part of the superstructure of said bridge shall give a clear headroom of not less than ten feet above extreme known high-water mark: *Provided*, That all spans shall be so located as to afford the greatest possible accommodation to the river traffic, and a draw-opening shall, if practicable, be located next or near shore: *Provided also*, That if the physical characteristics of the locality so require, and the interests of navigation be not injured thereby, the lengths of the fixed spans or the number of draw-openings may be reduced: *Provided, also*, That for any two adjacent draw-openings of two hundred feet each one draw-opening of three hundred feet may be substituted, if, in the opinion of the Secretary of War, the interests of navigation be not injured thereby.

SEC. 3. That all draw-spans authorized by this act shall be operated by steam or other reliable mechanical power, and shall be opened promptly upon reasonable signal for the passage of boats, except when trains are passing over said span or spans; but in no case shall unnecessary delay occur in opening said draw after the passage of trains; and also that in case the opening of a draw is delayed by reason of the passing of a train after the signal has been given from a boat ready to pass through the draw shall be opened for the passage of such boat before another train is allowed to pass over the said span or spans; nor shall there be any unnecessary delay in the passage of trains over the bridge.

SEC. 4. That all piers shall be built parallel with the current of the river at that stage of water which is most important for navigation, and the bridge itself shall be built as nearly as may be at right angles thereto; and that riprapping or other protection for imperfect foundations which will lessen the required water-way shall not be permitted; and also that piers which will produce cross-currents or bars dangerous to navigation shall not be constructed; and if, after construction any piers or accessory works are found to produce the above-mentioned effects, or if any riprapping or other protection prohibited by this section is found to exist, the nuisance shall be abated or corrected under the direction of the Secretary of War, or at the expense of the company or persons owning, controlling, or operating said bridge.

SEC. 5. That the approaches to said bridge shall be so designed and constructed as not to interfere with the free discharge of said river in seasons of flood; and any encroachment on the high-water cross-section by piers, solid embankments, or otherwise which will result in unduly accelerating the high-water current at the site of the bridge shall not be allowed.

SEC. 6. That any corporation, company, or persons owning, controlling, or operating the bridge built under the authority of this act shall build and maintain at all times, as accessory works to such bridge, such booms, piers, dikes, guard fences, and similar devices as may be necessary to insure at all times a permanent channel for a sufficient distance above and below the bridge site, and for the guiding of ratts, steam-boats, and other water-craft safely under or through said bridge; and if at any time after the construction of the bridge and its accessory works the approaches to draw-openings, channels spans, or raft-passages in said bridge are found to be dangerous or difficult of access by any important class of river traffic, the Secretary of War may, upon the recommendation of the Chief of Engineers, United States Army, order the corporation, company, or persons owning, controlling, or operating said bridge to construct, under his directions, and to maintain such additional sheer-booms, dikes, and other devices as will obviate the difficulty mentioned, which additional sheer-booms, dikes, and other devices shall be built and maintained at their own expense by said company or persons; and that said company or persons shall maintain, at their own expense, from sunset to sunrise throughout the season of navigation, such lights and other signals on said bridge as may be required by the Light-House Board for the security of navigation.

SEC. 7. That the bridge authorized to be constructed by this act shall be located and built under and subject to such regulations for the security of navigation on said river as the Secretary of War shall prescribe; and to secure that object said corporation shall submit for his examination a design and drawings of the bridge, piers, approaches, and accessory works, and a map of the location, giving, for a space of at least three miles above and one mile below the proposed location, the topography of the banks of the river and the shore-lines at high and low water. This map shall be accompanied by

others drawn on the scale of one inch to two hundred feet, giving, for a space of one-half a mile above the line of the proposed bridge and one-quarter of a mile below, an accurate representation of the bottom of the river, by contour lines two feet apart, determined by accurate soundings, and also showing over the the whole width of this part of the river the force and directions of the current at low water, at high water, and at least one intermediate stage by triangulated observations on suitable floats. The maps shall also show the location of other bridges in the vicinity, and shall give such information as the Secretary of War may require for a full and satisfactory understanding of the subject, and the construction of the proposed bridge shall not be commenced until the location and plans thereof are approved by the Secretary of War.

SEC. 8. That any bridge constructed under the authority of this act shall be built under the general supervision of the Secretary of War, and no changes or alterations in plans shall be made during construction of said bridge or after its completion, unless said changes or alterations conform to the provisions of this act and are authorized by the Secretary of War. That such alterations and changes as may be required by the Secretary of War in said bridge so as to preserve free and convenient navigation shall be made under the direction of the Secretary of War, at their own expense, by the company or persons owning, controlling, or operating said bridge. That during origiual construction or in carrying out any authorized changes or repairs of said bridge a navigable channel shall be preserved at the site of the bridge at all times, and the water-way of the river shall not be obstructed to a greater extent than is absolutely necessary, and such lights and buoys shall be kept on all coffer-dams, piles, and so forth, as may be necessary for the security of navigation.

SEC. 9. That whenever the Secretary of War has good reason to believe that any of the provisions of sections four, six, and eight of this act have not been complied with by the company or persons owning, controlling, or operating the bridge authorized under its provisions it shall be the duty of the Secretary of War, on satisfactory proof thereof, to require the said company or persons to comply with the provisions of said sections, and, on failure of said persons or company to comply with said requirements within a reasonable time, the Secretary of War shall proceed to cause the necessary work, in the form of additions, alterations, repairs, or removal of obstructions, to be made at the expense of the United States and shall refer the matter, without delay, to the Attorney-General of the United States, whose duty it shall be to institute, in the name of the United States, proceedings in the circuit courts of the United States in and for the district in which any portion of said obstruction or bridge may be, for the recovery of such expense, and all moneys accruing from such proceedings shall be covered into the Treasury of the United States.

SEC. 10. That all railroad companies desiring the use of the bridge authorized by this act shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same, and over the approaches thereto, upon the payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies.

SEC. 11. That the bridge constructed, maintained, aud operated under this act and according to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charges shall be made for the transportation over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation of said mails, troops, and munitions over the railroads and public highways leading to said bridge; and the United States shall have the right of way for postal telegraph and telephone purposes over said bridge.

SEC. 12. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years, and completed within four years from the date of approval thereof.

SEC. 13. That the right to alter, amend, or repeal this act is hereby expressly reserved; and the right to require the entire removal of the bridge constructed under the provisions of this act, at the expense of the owners thereof, whenever Congress shall decide that the public interests require it, is also expressly reserved.

Approved, August 29, 1890.

AN ACT making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and ninety-one, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, for the objects hereinafter expressed, for the fiscal year ending June thirtieth, eighteen hundred and ninety-one, namely:

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UNDER THE WAR DEPARTMENT.

* * * * * * *

BUILDINGS AND GROUNDS IN AND AROUND WASHINGTON.

For the improvement and care of public grounds, as follows:

For improvement of grounds north of Executive Mansion, one thousand dollars.

For improvement and maintenance of grounds south of Executive Mansion, four thousand dollars.

For ordinary care of green-houses and nursery, two thousand dollars.

For ordinary care of Lafayette Square, one thousand dollars.

For ordinary care of Franklin Square, one thousand dollars.

For care and improvement of Monument Grounds, five thousand dollars; and the officer in charge of public buildings and grounds may authorize the temporary use of a portion of the Monument Grounds or grounds south of the Executive Mansion or other reservations, in the District of Columbia, for a children's play-ground, under regulations to be prescribed by him.

For continuing improvement of reservation numbered seventeen and site of old canal northwest of same, ten thousand dollars: *Provided*, That no part thereof shall be expended upon other than property belonging to the United States.

For construction and repair of post-and-chain fences, and constructing stone coping around reservations, one thousand five hundred dollars.

For manure, and hauling the same, five thousand dollars.

For painting watchmen's lodges, iron fences, vases, lamps, and lamp posts, seven hundred and fifty dollars.

For purchase and repair of seats, one thousand dollars.

For purchase and repair of tools, two thousand dollars.

For trees, tree and plant stakes, labels, lime, whitewashing, and stock for nursery, three thousand dollars.

For removing snow and ice, one thousand two hundred dollars.

For flower-pots, twine, caskets, wire, splints, moss, and lycopodium, one thousand dollars.

For care, construction, and repair of fountains, one thousand five hundred dollars.

For abating nuisances, five hundred dollars.

For improvement, care and maintenance of various reservations, twelve thousand dollars, and hereafter no temporary structure of any kind shall be erected upon any reservation, except when authorized by special act of Congress.

For improvement, maintenance, and care of Smithsonian Grounds, including construction of asphalt roads and paths, eight thousand dollars.

For improvement, care, and maintenance of Judiciary Square, including grounds around the Pension Building and asphalt roads and walks leading to Pension Building, five thousand dollars.

That under appropriations herein contained no contract shall be made for making or repairing concrete or asphalt pavements in Washington City at a higher price than two dollars and twenty-five cents per square yard for a quality equal to the best laid in the District of Columbia prior to July first, eighteen hundred and eighty-six, and with a base of not less than six inches in thickness.

For repairs and fuel at the Executive Mansion as follows:

For care, repair, and refurnishing the Executive Mansion, twenty-five thousand dollars, to be expended by contract or otherwise, as the President may determine.

For portrait, and frame for same, of Grover Cleveland, ex-President of the United States, two thousand five hundred dollars, or so much thereof as may be necessary.

For fuel for the Executive Mansion, greenhouses, and stable, three thousand dollars.

For care and necessary repair of greenhouses, five thousand dollars.

LIGHTING THE EXECUTIVE MANSION AND PUBLIC GROUNDS: For gas, pay of lamplighters, gas-fitters, and laborers; purchase, erection, and repair of lamps and lamp-posts; purchase of matches, and for repairs of all kinds; fuel and lights for office, office

stables, watchmen's lodges, and for the greenhouses at the nursery, fourteen thousand dollars: *Provided*, That for each six-foot burner not connected with a meter in the lamps on the public grounds no more than twenty dollars shall be paid per lamp for gas, including lighting, cleaning, and keeping in repair the lamps, under any expenditure provided for in this act; and said lamps shall burn not less than two thousand six hundred hours per annum; and authority is hereby given to substitute other illuminating material for the same or less price, and to use so much of the sum hereby appropriated as may be necessary for that purpose.

For introducing electric lamps and wires into the Executive Mansion and connecting the same by under-ground cable with the source of electricity, seven thousand seven hundred dollars; and the sum appropriated for the purchase of gas may be applied to the purchase of gas or electric light.

For electric lights for three hundred and sixty-five nights from seven posts, at forty cents per light per night, one thousand and twenty-two dollars.

REPAIR OF WATER-PIPES: For repairing and extending water-pipes, purchase of apparatus to clean them, purchase of hose, and cleaning the springs and repairing and renewing the pipes of the same that supply the Capitol, the Executive Mansion, and the building for the State, War, and Navy Departments, two thousand five hundred dollars.

TELEGRAPH TO CONNECT THE CAPITOL WITH THE DEPARTMENTS AND GOVERNMENT PRINTING OFFICE: For care and repair of existing lines, one thousand two hundred and fifty dollars.

WASHINGTON MONUMENT: For the care and maintenance of the Washington Monument, namely: For one custodian at one hundred dollars per month; one steam engineer, at eighty dollars per month; one assistant steam engineer, at sixty dollars per month; one fireman, at fifty dollars per month; one assistant fireman at forty-five dollars per month; one conductor of elevator car, at seventy five dollars per month; one attendant on floor, at sixty dollars per month; one attendant on top floor, at sixty dollars per month; three night and day watchmen, at sixty dollars each per month; in all, eight thousand five hundred and twenty dollars.

For fuel, lights, oil, waste, packing, tools, matches, paints, brushes, brooms, lanterns, rope, nails, screws, lead, electric lights, heating apparatus, oil stoves for elevator car and upper and lower floor, repairs to engines, boilers, dynamos, elevator, and repairs of all kinds connected with the monument and machinery, and purchase of all necessary articles for keeping the monument, machinery, elevator, and electric-light plant in good order, two thousand six hundred dollars.

BUILDING FOR THE LIBRARY OF CONGRESS.

For continuing the construction of the building for the Library of Congress, and for each and every purpose connected with the same, eight hundred and fifty thousand dollars.

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MISCELLANEOUS OBJECTS.

SURVEY OF NORTHERN AN NORTHWESTERN LAKES: For printing and issuing charts for use of navigators and electrotyping plates for chart-printing, two thousand dollars.

For surveys, additions to, and correcting engraved plates, ten thousand dollars.

TRANSPORTATION OF REPORTS AND MAPS TO FOREIGN COUNTRIES: For the transportation of reports and maps to foreign countries, through the Smithsonian Institution, one hundred dollars.

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HARBOR OF NEW YORK: For prevention of obstructive and injurious deposits within the harbor and adjacent waters of New York City:

For pay of crew and maintenance of steamer Argus, eight thousand dollars;

For pay of crew and maintenance of new vessels to be purchased or constructed, ten thousand dollars;

For pay of inspectors and deputy inspectors, office force, and expenses of office, fifteen thousand dollars; in all, thirty-three thousand dollars.

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Approved, August 30, 1890.

AN ACT granting the use of certain lands to the town of New Haven, Connecticut, for a public park.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is hereby granted to the town of New Haven, in the State of Connecticut, the right to occupy, improve, and control, for the purposes of a public park, for the use and benefit of citizens of the United States and for no other purposes whatever, the tract of land owned by the United States which is situated on the east shore of New Haven Harbor, containing thirty acres, more or less, known as the Fort Hale tract, and partly occupied by an abandoned earth-work of that name, said tract being bounded northerly by the north side of the roadway leading to said tract, easterly by lands owned by various private parties, and southerly and westerly by New Haven Harbor, upon the following conditions and provisions:

First. That before beginning any use or improvement of said land the said town shall present to the Secretary of War detailed plans of such improvement and shall have received his approval thereof.

Second. That said town shall have and exercise power to make and enforce police regulations concerning said tract, and shall protect said earthwork from injury or defacement.

Third. That the United States reserves to itself the fee in said tract and the right to resume possession and occupy any portion thereof whenever, in the judgment of the President, the exigency arises that should require the use and appropriation of the same for the public defense or otherwise, or for such other disposition as Congress may determine, without any claim for compensation to said town for improvements thereon or damages on account thereof.

Approved September 1, 1890.

AN ACT to authorize the construction of a bridge across the Little Tennessee River at or near Niles' Ferry, Tennessee.

Be it ena ted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Knoxville Southern Railroad Company, a corporation organized under the laws of the State of Tennessee, be, and is hereby, authorized to construct and maintain a bridge, and approaches thereto, over the Little Tennessee River at or within two miles of Niles' Ferry, Tennessee. Said bridge shall be constructed to provide for the passage of railway trains, and, at the option of the corporation by which it may be built, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot-passengers, for reasonable rates of toll, to be fixed by said company; and the Secretary of War shall have the right, from time to time, to revise, prescribe, and determine such rates of tolls.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, and it shall enjoy the rights and privileges of other post-roads in the United States, and the same is hereby declared to be a post-route, upon which also no higher charge shall be made for the transmission over the same of the mail, troops, and munitions of war of the United States than the rate per mile their transmission over the railroad leading to said bridge, and equal privileges in the use of said bridge shall be granted to all telegraph companies, and the United States shall have the right of way across said bridge for postal-telegraph purposes; that the said bridge shall be so constructed, either by draw-span or otherwise, that a free and unobstructed passage-way may be secured to all water-craft navigating said river at the point aforesaid: *Provided*, That if said bridge authorized to be constructed under this act shall be constructed as a draw-bridge, the draws shall be opened promptly upon the reasonable signals for the passage of boats or vessels; and said corporation shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe.

SEC. 3. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same, and over the approaches thereto, upon the payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon the hearing of the allegations and proofs of the parties.

SEC. 4. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a

design and drawings of the bridge, and a map of the location, giving, for the space of one mile below and one mile above the proposed location, the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the construction of said bridge shall not be commenced; and should any change be made in the plan of said bridge during the progress of construction, such change shall be submitted to and subject to the approval of the Secretary of War.

SEC. 5. That the right to alter, amend, or repeal this act is hereby expressly reserved; and any alterations or changes that may be required by the Secretary of War in the bridge constructed under this act, or its entire removal, shall be made by the corporation owning or controlling the same, at its own expense. Furthermore, if the construction of said bridge shall not be commenced within two and completed within four years after the passage of this act all privileges conferred hereby and this act shall become null and void.

Approved, September 2, 1890.

AN ACT for the erection of a bridge across the Missouri River between the city of Saint Charles, Missouri, and the county of Saint Louis, Missouri.

Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, That the Saint Charles Ponton Bridge Company, a corporation duly organized and existing under the laws of the State of Missouri, its successors and assigns, be, and are hereby, authorized to construct and maintain a floating ponton bridge, and approaches thereto, across the Missouri River between the city of Saint Charles, in the State of Missouri, and Saint Louis County, in the State of Missouri, at some point at least one quarter of a mile from any other bridge, to be selected consistent with the interests of river navigation. Said bridge shall be constructed to provide for the passage of wagons and vehicles of all kinds, steam and street cars, animals, foot-passengers, and for all road travel, for such reasonable rates of toll, and under such reasonable rules and regulations as may be prescribed by said corporation, its successors and assigns, and to be approved from time to time by the Secretary of War.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the rail-road or public highways leading to the said bridge, and it shall enjoy the rights and privileges of other post-roads in the United States; and equal privileges in the use of said bridge shall be granted to all telegraph companies; and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes.

SEC. 3. That said bridge shall be constructed as a ponton draw-span bridge, and shall contain a ponton draw-span of not less than four hundred feet in length, which draw-span shall be maintained over the main channel of the river at an accessible and navigable point, and the piers of said bridge shall be parallel with, and the bridge itself at right angles to, the current of the river: *Provided also*, That said draw shall be opened promptly by said company, upon reasonable signal, for the passage of boats and rafts, and said company or corporation shall maintain, at its own expense, from sunset until sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe. No bridge shall be erected or maintained under the authority of this act which shall at any time substantially or materially obstruct the free navigation of said river, and if any bridge erected under such authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction; and all such alterations shall be made and all such obstructions be removed at the expense of the owner or owners of said bridge; and in case of any litigation arising from any obstruction, or alleged obstruction, to the free navigation of said river, caused or alleged to be caused by said bridge, the case may be brought in the district court of the United States of the State of Missouri in which any portion of said obstruction or bridge may be located: *And provided further*, That nothing in this law shall be construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

SEC. 4. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said

river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving, for the space of one-half mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the currents at all stages, and the soundings accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built; and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War.

SEC. 5. That the right to alter, amend, or repeal this act is hereby expressly reserved. And the right to require any changes in said structure, or its entire removal, at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interests requires it, is also expressly reserved.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof.

Approved, September 2, 1890.

AN ACT to authorize the construction of two bridges across Bœuf River, Louisiana.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the New Orleans, Natchez and Fort Scott Railway Company, or its successors, a corporation created and existing under the laws of the State of Louisiana, be, and is hereby, authorized to construct and maintain a bridge and approaches thereto over Bœuf River, at or near to the "cut off" north of Rayville, in Richland Parish, on a line to Oak Ridge, in Morehouse Parish, in the State of Louisiana; said bridge shall be constructed to provide for the passage of railroad trains and, at the option of the corporation by which it is built, may be used for the passage of wagons and vehicles of all kinds, transit of animals, and for foot-passengers, for reasonable rates of toll, to be fixed by said company and approved by the Secretary of War.

SEC. 2. That the New Orleans, Natchez and Fort Scott Railway Company, or its successors as aforesaid, is hereby also authorized to construct and maintain a bridge and approaches thereto over Bœuf River, on the eastern line of Caldwell Parish and near a line from Winnsboro, in Franklin Parish, to Cuba, in Caldwell Parish, or to Monroe, in Ouachita Parish, on the Ouachita River; said bridge shall be constructed to provide for the passage of railway trains and, at the option of the corporation by which it is built, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, for foot-passengers, for reasonable rates of toll to be fixed by said company and approved by the Secretary of War.

SEC. 3. That the two bridges built under this act and subject to its limitations shall be lawful structures, and shall be recognized and known as post-routes, and shall enjoy the rights and privileges of other post-roads in the United States; that no higher charges shall be made for the transmission over the same of the mail, troops, and munitions of war of the United States, or for through railway passengers or freight passing over said bridges, than the rate per mile for their transmission over the railroads leading to said bridges; and equal privileges in the use of the said bridges shall be granted to all telegraph companies, and the United States shall have the right of way across the said bridges for postal-telegraph purposes; that the said bridges shall be constructed either by draw, span, or otherwise, so that a free and unobstructed passage-way may be secured to all water craft navigating said river at the points aforesaid: *Provided*, That if the said bridges authorized to be constructed under this act shall be constructed as drawbridges, the draws shall be opened promptly upon reasonable signals for the passage of boats or vessels; and said corporation shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on the said bridges as the Light-House Board shall prescribe.

SEC. 4. That the bridges authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, designs and drawings of the said bridges, and a map of the location of each, giving the topography of the banks of the river, the shore-lines at high and low water, and the direction and strength of the current at different stages, the location of any other bridge or bridges, within one mile thereof, and such further information as may be required for a satisfactory understanding of the subject; and said bridges shall not be constructed

until the plan and location is approved by the Secretary of War. All litigation which shall be had in regard to the said bridges shall be in the circuit court of the United States in whose jurisdiction the said bridges are located.

SEC. 5. That the right to alter, amend, or repeal this act is hereby expressly reserved; and any alterations or changes that may be required by the Secretary of War in the bridges constructed under this act shall be made by the corporation owning or controlling the same, at its own expense. Furthermore, if the construction of the said bridges shall not be completed within two years after the passage of this act all the privileges conferred hereby, and this act, shall become null and void.

Approved September 4, 1890.

AN ACT authorizing the Lexington Pontoon Bridge Company to construct and maintain a pontoon bridge across the Missouri River, and to legalize the bridge already constructed, at the city of Lexington, in the State of Missouri.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Lexington Pontoon Bridge Company, a corporation having authority from the State of Missouri, its successors and assigns, to build, construct, and maintain a pontoon wagon and foot bridge across the Missouri River at some convenient point in or near the corporate limits of the city of Lexington, in Lafayette County, in said State, and extending to the county of Ray, opposite thereto.

SEC. 2. That said bridge shall be constructed with one suitable pontoon-draw of not less than five hundred feet in width, located over the main channel of said river, which said draw shall be opened promptly upon reasonable signal to allow the passage of boats: *Provided*, That said bridge shall not interfere with the place for landing of steamboats at Lexington.

SEC. 3. That said bridge shall be built and located under and subject to such regulations for the security of the navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the currents at all stages, and the soundings accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be commenced or built, and should any change be made in the plan of said bridge during the progress of construction such changes shall be subject to the approval of the Secretary of War.

SEC. 4. The said company or corporation shall maintain, at its own expense, from sunset till sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe.

SEC. 5. That the right is reserved in Congress to amend, alter, or repeal this act at any time, without any cost or damage to the said United States.

Approved, September 13, 1890.

AN ACT Making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums of money be, and are hereby, appropriated, to be paid out of any money in the Treasury not otherwise appropriated, to be immediately available, and to be expended under the direction of the Secretary of War, for the construction, completion, repair, and preservation of the public works hereinafter named:

Improving harbor at Rockland, Maine: Continuing improvement, thirty-seven thousand five hundred dollars.

Improving harbor at York, Maine: Continuing improvement, ten thousand dollars.

For the construction of a breakwater from Mount Desert to Porcupine Island, Maine: Continuing improvement, fifty thousand dollars.

Improving harbor at Portland, Maine: Continuing improvement, forty thousand dollars.

Improving harbor at Camden, Maine: Continuing improvement, six thousand dollars.

Improving harbor at Back Cove, Portland Harbor, Maine: Continuing improvement, twenty-five thousand dollars.

Improving harbor at Rockport, Maine: Completing improvement, five thousand dollars.

Improving Moose-a-bec Bar, Maine: Continuing improvement, fifteen thousand dollars.

Improving harbor at Belfast, Maine: Ten thousand dollars.

Improving Portsmouth Harbor, New Hampshire, by removing Pier Rock to depth of twelve feet at mean low water: To complete improvement, thirteen thousand dollars.

Improving harbor of refuge at Little Harbor, New Hampshire: Continuing improvement, forty thousand dollars.

Improving harbor at Burlington, Vermont: For repairs, twenty thousand dollars.

Improving harbor at Gordon's Landing, Lake Champlain, Vermont: To complete breakwater, six thousand dollars.

Improving harbor at Boston, Massachusetts: Continuing improvement, one hundred and forty-five thousand dollars, of which sum seven thousand dollars to be used in widening Nantasket Beach Channel; twenty-five thousand dollars in extending main ship channel from its termination at the southeast corner of Grand Junction Wharf eastwardly toward Jeffrey's Point, and twenty thousand dollars for continuing improvement of Charles River: *Provided*, That no expenditure, of said twenty thousand dollars shall be made until the draws in the Arsenal street and Market street bridges, shall be made to conform to the projected channel without cost to the United States.

Improving harbor at Lynn, Massachusetts: Continuing improvement, fifteen thousand dollars, and the engineers in charge shall expend the whole or part of this appropriation, at their discretion within the lines of the Harbor Commissioners.

Improving harbor at Nantucket, Massachusetts: Continuing improvement, twenty-five thousand dollars.

Improving harbor at Newburyport, Massachusetts: Continuing improvement, twenty-five thousand dollars.

Improving harbor at Plymouth, Massachusetts: Continuing improvement and repairs of work on Long Beach, eight thousand dollars.

Improving harbor at Provincetown, Massachusetts: Completing existing project, seven thousand five hundred dollars.

Improving harbor at Scituate, Massachusetts: Continuing improvement, ten thousand dollars.

Improving harbor at Gloucester, Massachusetts: Continuing improvement, fifteen thousand dollars.

Improving harbor at Wareham, Massachusetts: Continuing improvement, five thousand dollars.

Improving harbor at New Bedford, Massachusetts: Continuing improvement, ten thousand dollars.

Improving harbor at Hingham, Massachusetts: Continuing improvement, five thousand dollars.

Improving harbor at Winthrop, Massachusetts: Continuing improvement, five thousand dollars.

Improving harbor at Hyannis, Massachusetts: Continuing improvement, eight thousand dollars.

Improving harbor at Vineyard Haven, Massachusetts: Continuing improvement, ten thousand dollars.

Improving harbor at Wellfleet, Massachusetts: Continuing improvement, four thousand dollars.

Improving national harbor of refuge at Sandy Bay, Cape Ann, Massachusetts: Continuing improvement, one hundred and fifty thousand dollars.

Improving harbor at Manchester, Massachusetts: Continuing improvement, five thousand dollars.

Improving Martha's Vineyard inner harbor at Edgartown, Massachusetts, for dredging, two thousand dollars.

Improving Salem Harbor, including South River, Massachusetts, fourteen thousand dollars.

Improving Stage Harbor at Chatham, Massachusetts, five thousand dollars.

Improving Westport Harbor and East and West Branch of Westport River, Massachusetts, one thousand dollars, to be applied in extending the jetty on Horse Neck Point and to dredging in Westport Harbor.

Improving harbor at Block Island, Rhode Island: Continuing improvement, fifteen thousand dollars; and the wharf on the land side of the inner harbor is hereby conveyed to the town of New Shoreham for the public use of said town; but no tolls or charges shall ever be exacted for the use of said wharf by public vessels of the United States or freight carried in such vessels.

Improving harbor at Newport, Rhode Island: Continuing improvement, twelve thousand five hundred dollars.

Improving harbor at Greenwich Bay, Rhode Island: To complete, two thousand dollars.

Improving cove near southeast extremity of Coaster's Harbor Island, Rhode Island, and water-way between said island and Rhode Island, to complete, five thousand five hundred dollars.

Constructing national harbor of refuge at or near Point Judith, Rhode Island: Commencing construction, seventy-five thousand dollars.

Improving harbor at Bridgeport, Connecticut: Continuing improvement, twenty thousand dollars, of which fifteen thousand dollars shall be expended in constructing breakwater between the Tongue and inner beacon, and five thousand dollars to complete improvement above the bridge.

Improving harbor at Black Rock, Connecticut: Continuing improvement, five thousand dollars.

Constructing breakwaters at New Haven, Connecticut, in accordance with the plans submitted by Chief of Engineers in report for eighteen hundred and eighty-nine, page six hundred and seventy-eight: Continuing improvement, one hundred and twenty thousand dollars.

Improving harbor at New Haven, Connecticut: Continuing improvement, fifteen thousand dollars.

Improving harbor at Norwalk, Connecticut: Completing improvement, four thousand dollars.

Improving harbor at Wilson's Point, Connecticut: For widening and deepening channel, thirty thousand dollars.

Improving harbor at Stonington, Connecticut: Continuing improvement, twelve thousand five hundred dollars.

Improving harbor at Stamford, Connecticut: Completing improvement, five thousand dollars.

Improving harbor at Five Mile River, Connecticut: Continuing improvement, five thousand dollars.

Improving harbor at Milford, Connecticut: Completing improvement, two thousand five hundred dollars.

Improving harbor of refuge, Duck Island Harbor, on Long Island Sound, Connecticut: twenty-five thousand dollars.

Improving harbor at Clinton, Connecticut: Continuing improvement, three thousand five hundred dollars.

Improving harbor at Buffalo, New York: Continuing improvement, three hundred thousand dollars, for continuance of concrete construction and repairs and extension of breakwater.

Improving breakwater at Rouse's Point, New York: Continuing improvement, fifteen thousand dollars.

Improving harbor at Canarsie Bay, New York: Continuing improvement, five thousand dollars.

Improving harbor at Charlotte, New York: Continuing improvement, twenty-five thousand dollars.

Improving harbor at Dunkirk, New York: Continuing improvement, twenty thousand dollars.

Improving harbor at Flushing Bay, New York: Continuing improvement, twenty thousand dollars.

Improving channel at Gowanus Bay, New York: Continuing improvement, by deepening to twenty-one feet mean low water and widening the channel to four hundred feet on the northerly side from the foot of Percival street, along the wharves to the twenty-three foot curve, opposite the entrance to the Erie Basin, sixty thousand dollars.

Improving Bay Ridge Channel in Gowanus Bay, New York Harbor, by dredging out and opening the same from a point at its junction with the Gowanus Creek Channel (near twenty-eighth street), southerly therefrom along and in front of Gowanus Bay and Bay Ridge to a point where the said Bay Ridge Channel so to be opened encounters a twenty-one foot contour or depth of water, so that the channel so to be opened shall be of a uniform depth of twenty-one feet and width of four hundred feet at low water, one hundred thousand dollars.

Improving harbor at Great Sodus Bay, New York: Continuing improvement, ten thousand dollars.

Improving harbor at Little Sodus Bay, New York: Continuing improvement, thirteen thousand dollars.

Improving harbor at Greenport, New York: Continuing improvement, five thousand dollars.

Improving harbor at Oak Orchard, New York: Continuing improvement, five thousand dollars.

Improving harbor at Ogdensburgh, New York: Continuing improvement, forty-two thousand dollars, including new project.

Improving harbor at Olcott, New York: Continuing improvement, thirty thousand dollars.

Improving harbor at Oswego, New York: Continuing improvement, thirty thousand dollars.

Improving harbor at Rondout, New York: Repairing existing works, five thousand dollars.

Improving Tonawanda Harbor and Niagara River, New York: Continuing improvement, seventy-five thousand dollars.

Improving New York Harbor, New York: Completing improvement, one hundred and sixty thousand dollars.

Improving harbor at Saugerties, New York: Continuing improvement, ten thousand dollars.

Improving harbor at Port Chester, New York: Continuing improvement, five thousand dollars.

Improving harbor at Glen Cove, New York: Continuing improvement, fifteen thousand dollars.

Improving harbor at Pultneyville, New York, two thousand dollars.

Improving channel between Staten Island and the New Jersey shore, New York and New Jersey: Continuing improvement, fifteen thousand dollars.

Improving Arthur Kill, between Staten Island and the New Jersey shore, New York and New Jersey: Dredging and straightening channel near Staten Island Bridge, and removing the point of land westerly of same, seven thousand dollars.

Improving harbor at Port Jefferson Inlet on the project to give a channel ten feet deep and two hundred feet wide, twenty-five thousand dollars.

Improving harbor at Plattsburgh, New York: For repairs and extension of breakwater, to complete, thirty-two thousand five hundred dollars.

Improving harbor at Larchmont, on Long Island Sound, New York: five thousand dollars.

Improving harbor at Huntington, Long Island, New York, ten thousand dollars.

Improving harbor at Raritan Bay, New Jersey: Continuing improvement, forty thousand dollars, one-half of which may be used in dredging bar between South Amboy and Great Beds Light.

Improving habor at Erie, Pennsylvania: Continuing improvement, forty thousand dollars.

Improving the harbor of Philadelphia: For removal of Smith's Island and Windmill Island, in the State of Pennsylvania, and Petty's Island, in the State of New Jersey, or such parts of them and the shoals adjacent thereto as may be required, and for the improvement of the harbor between the cities of Philadelphia, Pennsylvania, and Camden, New Jersey, two hundred thousand dollars: *Provided*, That contracts may be entered into by the Secretary of War for the work required for the improvement of the Delaware River between the cities of Philadelphia, Pennsylvania, and Camden, New Jersey, according to the plan reported by the Board of Engineers and transmitted to Congress April seventh, eighteen hundred and eighty-eight, and printed as House Executive Document two hundred and sixty, Fiftieth Congress, first session, or such modifications thereof as may be determined upon by the Secretary of War: *Provided*, That the cost of the improvement shall not be thereby increased, to be paid for as appropriations may from time to time be made by law.

Improving ice-harbor at Marcus Hook, Pennsylvania: Continuing improvement, five thousand dollars.

Improving Delaware Breakwater, Delaware: Continuing improvement, eighty thousand dollars.

Improving ice-harbor at New Castle, Delaware: Completing improvement, eight thousand one hundred dollars.

Improving harbor at Wilmington, Delaware: Continuing improvement, thirty thousand dollars.

The Secretary of War is directed to appoint a commission of three persons, one of whom shall be a civil engineer of experience in the improvement of rivers and harbors, who shall proceed to make an accurate survey of the tidal streams which form the harbor of Wilmington, Delaware, making all necessary observations to obtain all the data required for a plan for the permanent improvement of the harbor to suit the present and prospective wants of commerce and navigation; and that said commissioners shall, as soon as possible, make to the Secretary of War a report, submitting with it a plan for the improvement of said harbor.

Improving harbor at Baltimore, Maryland: Continuing improvement, three hundred and forty thousand dollars: *Provided*, That such contracts as may be desirable may be entered into by the Secretary of War for the completion of the existing project, or any part of same, to be paid for as appropriations may from time to time be made by law.

Improving harbor at Breton Bay, Maryland: Continuing improvement, five thousand dollars.

Improving harbor at Cambridge, Maryland: Continuing improvement, five thousand dollars.

Improving harbor at Norfolk and its approaches, Virginia: Continuing improvement, one hundred and fifty thousand dollars, fifty thousand dollars of which shall be expended in improving the approach to the inner harbor and the United States navy-yard at Norfolk, by increasing anchorage between Lambert's Point and Fort Norfolk.

Improving harbor at Cape Charles City and approaches by Chenton Inlet, Virginia: Twenty-five thousand dollars, for dredging only.

Improving harbor at Onancock, Virginia, six thousand dollars.

Improving harbor at Beaufort, North Carolina: Continuing improvement, fifteen thousand dollars.

Improving the inland water-way between Beaufort and New River, North Carolina: Continuing improvement, fifteen thousand dollars.

Improving harbor at Charleston, including Sullivan's Island, South Carolina: Continuing improvement, three hundred and seventy thousand dollars, of which five thousand dollars shall be expended on Mount Pleasant shore of inner harbor of Charleston, South Carolina.

Improving harbor at Georgetown, South Carolina: Continuing improvement, eight thousand dollars.

Improving Winyaw Bay, South Carolina: Continuing improvement, one hundred thousand dollars.

Improving harbor at Brunswick, Georgia: Continuing improvement, thirty-five thousand dollars.

Improving Cumberland Sound, Georgia and Florida: Continuing improvement, one hundred and twelve thousand five hundred dollars.

Improving harbor at Savannah, Georgia: Continuing improvement on extended project, three hundred and fifty thousand dollars.

Improving harbor at Darien, Georgia: twenty-five thousand dollars.

Improving harbor at Apalachicola Bay and the mouth of the river, Florida: Continuing improvement, twenty thousand dollars.

Improving harbor at Cedar Keys, Florida: Continuing improvement, two thousand five hundred dollars, a part of which may be expended at Derrick Island Gap on the inside channel from Suwanee River.

Improving harbor at Pensacola, Florida: Continuing improvement, twenty-five thousand dollars.

Improving harbor at Tampa Bay, Florida: Continuing improvement, twenty-five thousand dollars.

Improving entrance to harbor at Key West, Florida, forty thousand dollars.

Improving, dredging, and deepening the channel of Charlotte Harbor and Pease Creek, Florida, to the pier at Punta Gorda, the terminus of the Florida Southern Railroad, thirty-five thousand dollars.

Improving harbor at Saint Augustine, Florida: To complete protection from erosion, according to the estimate of Captain W. M. Black under date of May twenty-fourth, eighteen hundred and ninety, twenty thousand dollars.

Improving harbor at Mobile, Alabama, up to the mouth of Chickasabogue Creek: Continuing improvement, three hundred and fifty thousand dollars.

Improving harbor at Biloxi, Mississippi: Continuing improvement, nine thousand dollars.

Improving mouth and passes of Calcasieu River, Louisiana, according to the plan reported by Major W. H. Heuer Corps of Engineers, in eighteen hundred and eighty-six, and confirmed by Captain W. L. Fisk, Corps of Engineers, in his report of November, eighteen hundred and eighty-eight, seventy-five thousand dollars.

Improving harbor at Sabine Pass, Texas: Continuing improvement, three hundred thousand dollars, and of this amount the Secretary of War may, in his discretion, use fifty thousand dollars, or so much of said fifty thousand dollars as may be necessary, for dredging.

Improving and maintaining ship-channel in Galveston Bay, Texas, from Bolivar Channel through Morgan's Cut and Morgan's Channel constructed through Morgan's Point to the San Jacinto River, forty thousand dollars.

Improving entrance to Galveston Harbor, Texas: Continuing improvement, five hundred thousand dollars: *Provided*, That contracts may be entered into by the Secretary

of War for such materials and work as may be necessary to carry out the plan contained in the report of the Chief of Engineers for eighteen hundred and eighty-six for the improvement of that harbor, to be paid for as appropriations may from time to time be made by law.

Improving harbor at Ashtabula, Ohio: Continuing improvement, forty thousand dollars.

Improving harbor at mouth of Black River, Ohio: Continuing improvement, twelve thousand dollars.

Improving harbor at Cleveland, Ohio: Continuing improvement, seventy-five thousand dollars.

Improving harbor at Fairport, Ohio: Continuing improvement, thirty thousand dollars, of which eight thousand seven hundred dollars may in the discretion of the Secretary of War be expended in dredging and deepening the channel of Grand River from its mouth to the new docks on the west side of the same.

The owners of dock property abutting on the East Government pier on Grand River shall have the right to load and unload coal, ore, and other freight over so much of said pier as lies north of the inner shore-line represented on map in the report of the Chief of Engineers of eighteen hundred and eighty-one, on prepayment of such rent therefor and under such limitations as to time and use and such other conditions of such right as shall be prescribed by the Secretary of War and always revocable by him, or by Congress.

Improving harbor at Huron, Ohio: Continuing improvement, in amended project to give sixteen feet depth at low water, sixteen thousand dollars. The owners of dock property abutting on the old Government pier on the east side of Huron River shall have the right to load and unload coal, ore, and other freight over so much of said pier as lies south of the shore line of Lake Erie, under such limitations as to time and use as shall be approved by the Secretary of War said right to be always revocable by him or Congress and in consideration thereof the owners of such dock property shall, at their own proper cost and expense, sufficiently repair, renew, and protect the portion of said pier south of said shore line, and do all necessary dredging in Huron River in front thereof; all such repairs, renewals, and dredging to be done under the supervision of the Chief of Engineers of the United States Army.

Improving harbor at Sandusky, Ohio: Continuing improvement, forty-five thousand dollars.

Improving harbor at Toledo, Ohio: Continuing improvement, two hundred thousand dollars.

Improving harbor at Toledo, Ohio: For clearing the old channel, five thousand dollars.

For ice-harbor at the mouth of Muskingum River, Ohio: For repairs, thirty thousand dollars.

Improving harbor at Port Clinton, Ohio: Continuing improvement, three thousand dollars.

Improving harbor at Vermillion, Ohio: For preservation of piers, two thousand dollars.

Improving outer harbor at Michigan City, Indiana: Continuing improvement, fifty thousand dollars.

Improving inner harbor at Michigan City, Indiana: Continuing improvement, seven thousand five hundred dollars, of which two thousand five hundred dollars may be expended for a new dump scow.

Improving harbor at Calumet, Illinois: Continuing improvement, twenty thousand dollars.

Improving harbor at Chicago, Illinois: Continuing improvement, one hundred thousand dollars.

Improving harbor at Waukegan, Illinois: Continuing improvement, thirty-five thousand dollars.

Improving harbor at Charlevoix and enterence to Pine Lake, Michigan: Continuing improvement, nine thousand dollars.

Improving harbor at Frankfort, Michigan: Continuing improvement, ten thousand dollars.

Improving harbor at Grand Haven, Michigan: Continuing improvement, seventy-five thousand dollars.

Improving harbor at Grand Marais, Michigan: Continuing improvement, fifty thousand dollars.

Improving harbor at Manistee, Michigan: Continuing improvement, fifty thousand dollars.

Improving harbor at Black Lake, Michigan: Continuing improvement, ten thousand dollars.

Improving harbor at Monroe, Michigan: Continuing improvement, five thousand dollars.

Improving harbor at Muskegon, Michigan: Continuing improvement, fifty thousand dollars, thirty-four thousand dollars of which to close gap as recommended by engineer in charge.

Improving harbor at Ontonagon, Michigan: Continuing improvement, ten thousand dollars.

Improving harbor at Pentwater, Michigan: Continuing improvement, eight thousand dollars.

Improving harbor of refuge at Portage Lake, Michigan: Continuing improvement, eight thousand dollars.

Improving harbor of refuge at Sand Beach, Michigan: For repairs, custody, and control of harbor and dredging the same, thirty thousand dollars.

Improving harbor at Saint Joseph, Michigan: Continuing improvement, twenty thousand dollars, five thousand of which shall be expended on the water channel leading to Benton Harbor.

Improving harbor at South Haven, Michigan: Continuing improvement, fifteen thousand dollars.

Improving harbor at White River, Michigan: Continuing improvement, seventeen thousand dollars.

Improving harbor at Marquette, Michigan: Continuing improvement, forty thousand dollars.

Improving harbor at Thunder Bay, Michigan: To restore fourteen-foot channel, five thousand five hundred dollars.

Improving harbor at Petoskey, Michigan: For breakwater and harbor of refuge, fifteen thousand dollars.

Improving harbor at Ahnapee, Wisconsin: Continuing improvement, six thousand dollars.

Improving harbor at Green Bay, Wisconsin: Continuing improvement, ten thousand dollars.

Improving harbor at Kenosha, Wisconsin: Continuing improvement, seventeen thousand five hundred dollars, two thousand five hundred dollars of the above appropriation to be expended in dredging the inner harbor.

Improving harbor at Kewaunee, Wisconsin: Continuing improvement, twenty thousand dollars.

Improving harbor at Manitowoc, Wisconsin: Completing improvement, eight thousand dollars; and the engineer in charge, with the approval of the Secretary of War, may use such part of the above appropriation in the construction of an outer breakwater as he may deem proper.

Improving harbor of refuge at Milwaukee, Wisconsin: Continuing improvement, eighty thousand dollars.

Improving harbor at Milwaukee, Wisconsin: Continuing improvement, six thousand dollars.

Improving harbor at Port Washington, Wisconsin: Continuing improvement, three thousand dollars.

Improving harbor at Racine, Wisconsin: Continuing improvement, seventeen thousand five hundred dollars.

Improving harbor at Superior Bay and Saint Louis Bay, Wisconsin: Continuing improvement, sixty-five thousand dollars.

Improving harbor at Sheboygan, Wisconsin: Continuing improvement, fifteen thousand dollars.

Improving harbor at Ashland, Wisconsin: Continuing improvement, sixty thousand dollars.

Improving harbor at Two Rivers, Wisconsin: Continuing improvement, three thousand dollars.

Improving Sturgeon Bay Canal harbor of refuge: For maintenance of channel and piers, three thousand dollars.

Improving Minnesota Point at Superior, Wisconsin: For the preservation of said point and the protection of the harbor at Superior Bay by the construction of said fences, four thousand eight hundred and ninety-five dollars.

Improving Harbor at Duluth, Minnesota: Continuing improvement, one hundred thousand dollars, of which sum forty thousand dollars shall be expended on the harbor basin and new channel east of Rice's Point and in the preservation and maintenance of the canal and piers at the harbor entrance, and sixty thousand dollars shall be expended on the channel west of Rice's Point and from thence along the northern shore of Saint Louis Bay to Grassy Point.

Improving harbor at Grand Marais, Minnesota: Continuing improvement, twenty-two thousand three hundred and fifty dollars.

Improving harbor at Agate Bay, Minnesota: Continuing improvement, twenty-five thousand dollars.

Improving harbor at Humboldt, California: Continuing improvement, eighty thousand dollars.

Improving harbor at Oakland, California: Continuing improvement, two hundred and fifty thousand dollars, one half of which may, in the discretion of the Secretary of War, be expended in dredging the entrance to the harbor.

Improving harbor at Wilmington, California: Continuing improvement, thirty-four thousand dollars.

Improving harbor at San Luis Obispo, California: Continuing improvement, forty thousand dollars.

Improving harbor at San Diego, California, sixty thousand five hundred dollars, of which sum five hundred dollars shall be expended for repairs, eight thousand dollars for dredging, and the remainder to commence construction of jetty on Zuninga Shoals.

That the Secretary of War is authorized and directed to appoint a board of three engineer officers of the United States Army, whose duty it shall be to examine the Pacific Coast between Points Duma and Capistrano with a view to determining the best location for a deep-water harbor. The said board shall report to the Secretary of War a project for said harbor, with the estimated cost of the same, who shall lay said report before Congress at its next session, with the views of the commission and of the Chief of Engineers of the United States Army thereon; and the sum of five thousand dollars, or so much thereof as may be necessary, is hereby appropriated for the purpose.

Improving entrance to harbor at Coos Bay, Oregon: Continuing improvement, one hundred and twenty-five thousand dollars.

Improving harbor at Yaquina Bay, Oregon: Continuing improvement, one hundred and sixty-five thousand dollars.

Improving harbor at Tillamook Bay, Oregon: Completing improvement, five hundred dollars.

Improving entrance to harbor at Nehalem Bay, Oregon, ten thousand dollars for commencement of jetty construction.

The Secretary of War is authorized and directed to appoint a board of three officers of the Corps of Engineers, United States Army, whose duty it shall be to re-examine the harbor at Port Orford, in the State of Oregon, with a view of minimizing the project and estimates of the proposed improvement for a harbor of refuge at that point to such proportions as will largely reduce the original estimate of the cost of such improvement heretofore made under the direction of the Secretary of War in pursuance of the previous action of Congress, and to report to the Secretary of War, on or before the first Monday in December next, the result of such re-examination, together with the reduced estimate of the cost of such improvement, in the event that such board shall determine that the same can be made on a less expensive scale than originally recommended, and the cost of such re-examination and re-estimate shall be paid by the Secretary of War out of the one hundred and fifty thousand dollars heretofore appropriated for the commencement of a breakwater at such point: *Provided, however*, That such expense shall not exceed the sum of five thousand dollars.

For the purchase of the two canals known as the Portage Lake and River Improvement Company Canal, from Keweenaw Bay to Portage Lake, and the Lake Superior Ship-Canal, Railway, and Iron Company Canal, from Portage Lake to Lake Superior, being the water communication across Keweenaw Point, Lake Superior, from Keweenaw Bay to Lake Superior, in the State of Michigan, by way of the Portage River and Lake and the artificial cut made by said companies to render them available to commerce and navigation, together with the works of improvement on Portage Lake; the harbor works upon Lake Superior and Keweenaw Bay, with all lands and franchises connected therewith, free from all incumbrances, three hundred and fifty thousand dollars: *Provided*, That for the purpose of preserving and continuing the use and navigation of said canals, the sum of ten thousand dollars for each of the present and the next fiscal year be appropriated, out of any money in the Treasury not otherwise appropriated, or so much thereof as may be necessary, to pay the actual expenses of operating and keeping said canals in repair; and that an itemized statement of said expenses shall accompany the annual report of the Chief of Engineers: *And provided further*, That no money appropriated for this purpose shall be available until a valid title to all of said premises shall be vested in the United States, nor until the State of Michigan shall have ceded to the United States exclusive jurisdiction over the same, during the time the United States shall be or remain the owner thereof, for all purposes except the administration of the criminal laws of said State and the service of civil process on the lands and right of way so conveyed. The balance of the appropriation, to wit, five thousand one hundred and

twenty-eight dollars and seventy cents, for examination of Portage Lake and Lake Superior Ship Canals, contained in the river and harbor act of August fifth, eighteen hundred and eighty-six, is hereby made available for each and every purpose connected with the establishment of new harbor lines in Portage Lake under the provisions of the act of June twentieth, eighteen hundred and ninety, authorizing and directing said establishment.

Improving Bagaduce River, Maine: Continuing improvement, four thousand dollars.

Improving Penobscot River, Maine: Continuing improvement, and for dredging near Stern's mill, twenty five thousand dollars

Improving Narragaugus River, Maine; Continuing improvement, seven thousand five hundred dollars.

Improving Kennebec River, Maine: Continuing improvement, fifty thousand dollars.

Improving Saco River, Maine: Continuing improvement, including breakwater and the construction of a proposed jetty opposite the same, sixty-five thousand dollars: *Provided*, That the whole of said sum may be used in the discretion of the Secretary of War in the construction of said proposed jetty.

Improving Harrisseckit kiver, Maine, ten thousand dollars.

Improving Saint Croix River, Maine, thirty-five thousand dollars; but upon the condition that the Government of the Dominion of Canada shall expend a like sum in the improvement of said river.

Improving Kennebunk River, Maine, at or near its mouth, twenty thousand dollars, the entire amount to be expended in repairs if necessary.

Improving Pleasant River, Maine: To complete improvement, three thousand five hundred dollars.

Improving Bellamy River, New Hampshire: Continuing improvement, ten thousand dollars.

Improving Cocheco River, New Hampshire, twenty-five thousand dollars.

Improving Otto Creek, Vermont: Continuing improvement five thousand dollars.

Improving Powow River, Massachusetts: Continuing improvement, five thousand dollars: *Provided*, That this sum shall not be expended until the towns of Amesbury and Salisbury, or either of them, shall have caused such a draw to be placed in the present bridge over said river as may be approved by the Secretary of War.

Improving Taunton River, Massachusetts: Continuing improvement, seven thousand dollars.

Improving Merrimac River at Mitchell's Falls, Massachusetts: Continuing improvement, ten thousand dollars.

Improving Weymouth River, Massachusetts: ten thousand dollars.

Improving Pawtucket River, Rhode Island: Continuing improvement, thirty thousand dollars.

Improving Providence River and Narragansett Bay, Rhode Island, Continuing improvement, fifty thousand dollars.

Improving Green Jacket Shoal, Providence River, Rhode Island: Continuing improvement, twenty-five thousand dollars.

Improving Pawcatuck River, Rhode Island: Completing improvement, sixteen thousand six hundred dollars.

Improving Connecticut River below Hartford, Connecticut: Continuing improvement, twelve thousand five hundred dollars.

Improving Housatonic River and for breakwater, Connecticut: Continuing improvement, thirty-five thousand dollars.

Improving Thames River, Connecticut, Continuing improvement, twenty thousand dollars, which may be expended at any point between Norwich and New-London.

Improving Mystic River, Connecticut, ten thousand dollars.

Improving Hudson River, New York: Continuing improvement, one hundred and fifty thousand dollars.

Improving Newtown Creek and Bay, New York: Continuing improvement, thirty-five thousand dollars, one fourth of said sum to be expended on the main branch of said creek between Maspeth avenue and Metropolitan avenue, and one fourth of said sum to be expended on the English Kills Branch of said creek.

Improving East River and Hell Gate, New York: Removing obstructions, two hundred thousand dollars.

Improving Harlem River, New York: Continuing improvement, two hundred and fifty thousand dollars; and the Secretary of War is directed to cause the low bridges now crossing said Harlem River to be replaced by other bridges at the expense of the owners thereof as soon as the necessary legislation, if any such legislation be necessary, shall have enabled the change in grade to the approaches of said bridges, thus required, to be made, the owners of said bridges being allowed a reasonable time in which to complete the work necessary for said approaches. Said bridges shall leave a clear space, between the

under sides thereof and the high water of spring tides, of twenty four feet, and shall be provided with draw-spans and draws of the width and length to be determined by the Secretary of War, and shall in all respects comply with this law and conform to the requirements of the Secretary of War: *Provided*, That the Secretary of War shall prescribe the times and regulations for the opening and operating of the draws in said bridges, but said draws shall not be opened except for vessels propelled by steam with or without vessels in tow; nor shall they be required to be opened at any times other than between ten o'clock in the forenoon and five o'clock in the afternoon.

Improving Grass River, New York: Completing improvement, six thousand dollars.

Improving Great Chazy River, New York, from its mouth on Lake Champlain to Champlain Village, ten thousand dollars.

Improving Patchogue River, New York, fifteen thousand dollars.

Improving Ticonderoga River, New York: Continuing improvement two thousand dollars.

Improving Wappinger's Creek, New York, from the falls to its mouth, thirteen thousand dollars.

Improving Brown's Creek, Sayville, Long Island, New York, twelve thousand dollars.

Improving shoal between Sister Islands and the Cross over light, Saint Lawrence River, New York, five thousand dollars.

Improving Passaic River above Newark, New Jersey: Continuing improvement, five thousand one hundred dollars, one thousand five hundred dollars of which, or so much thereof as may be necessary, shall be expended in making an examination and survey of said river.

Improving Maurice River, New Jersey: Continuing improvement, eight thousand dollars.

Improving Passaic River below Newark, New Jersey: Continuing improvement, forty thousand dollars.

Improving Raritan River, New Jersey: Continuing improvement, fifty thousand dollars.

Improving Shrewsbury River, New Jersey: Continuing improvement, ten thousand dollars, one-half of which shall be expended on the South Branch.

Improving South River, New Jersey: Continuing improvement, five thousand dollars.

Improving Squan River, New Jersey, by the removal of obstructions placed by the Government at the mouth of said river, if, in the discretion of the Secretary of War, the same should be done, two thousand dollars.

Improving Shoal Harbor and Compton's Creek, New Jersey, so as to give a channel four feet deep at mean low water, five thousand dollars.

Improving Elizabeth River, New Jersey, five thousand dollars.

Improving Mattawan Creek, New Jersey, two thousand five hundred dollars.

Improving Alloway Creek, New Jersey, six thousand dollars.

Improving Allegheny River, Pennsylvania: Continuing improvement, twenty thousand dollars.

Improving Schuykill River, Pennsylvania: Continuing improvement, forty-five thousand dollars.

Improving Delaware River, Pennsylvania and New Jersey: Continuing improvement, from Trenton to its mouth, two hundred and fifty thousand dollars, ten thousand dollars of which shall be expended in continuing improvement on the Rancocas River, one of the tidal tributaries of said river.

For continuing construction of the dam at Herr's Island in Allegheny River, near Pittsburgh, Pennsylvania, thirty-five thousand dollars.

That whenever the proceedings commenced by the United States against the Monongahela Navigation Company, a corporation organized under the laws of Pennsylvania to condemn lock and dam number seven constituting a part of the improvement in water communication in the Monongahela River between Pittsburgh in the State of Pennsylvania, and a point at or near Morgantown in the State of West Virginia, shall be finally determined, and the United States shall have acquired the title to said lock and dam number seven and its appurtenances, the Secretary of War be, and he is hereby, authorized and directed to negotiate for and purchase, at a cost not to exceed one hundred and sixty-two thousand dollars, lock and dam number six and its appurtenances, of the Monongahela Navigation Company, also constituting a part of said improvement. And the sum of one hundred and sixty two thousand dollars, or so much thereof as may be necessary, is hereby appropriated out of any moneys in the Treasury not otherwise appropriated, for consummating said purchase, the same to be paid on the warrant of the Secretary of War, upon full and absolute conveyance to the United States of the said

lock and dam number six and its appurtenances, of the said Monongahela Navigation Company.

In the event of the inability of the Secretary of War to make voluntary purchase of said lock and dam number six and its appurtenances for said sum of one hundred and sixty-two thousand dollars, or a less sum, then the Secretary of War is hereby authorized and directed to institute and carry to completion proceedings for the condemnation of said lock and dam number six and its appurtenances, said condemnation proceedings to be as prescribed and regulated by the provisions of the general railroad law of Pennsylvania, approved February nineteenth, eighteen hundred and forty-nine, and its supplements, except that the United States shall not be required to give any bond, and except that jurisdiction of said proceedings is hereby given to the circuit court of the United States for the western district of Pennsylvania with right of appeal by either party to the Supreme Court of the United States: *Provided*, That in estimating the sum to be paid by the United States, the franchise of said corporation to collect tolls shall not be considered or estimated; and the sum of five thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any moneys in the Treasury not otherwise appropriated, to pay the necessary costs of said condemnation proceedings; and upon final judgment being entered therein the Secretary of War, if in his opinion the judgment is reasonable, is hereby authorized and directed to draw his warrant on the Treasury for the amount of said judgment and costs, and said amount for the payment thereof is hereby appropriated out of any moneys in the Treasury not otherwise appropriated. And when said lock and dam number six and its appurtenances shall have been acquired by the United States, whether by purchase or condemnation, the Secretary of War shall take charge thereof, and the same shall thereafter be subject to the provisions of section four of an act entitled "An act making appropriations for the construction, repair, and preservation for certain public work on rivers and harbors, and for other purposes," approved July fifth, eighteen hundred and eighty-four.

Improving the Ohio River by the construction of a movable dam at or below the mouth of Beaver River, Pennsylvania, at such locality as the Secretary of War may consider most advantageous, two hundred and fifty thousand dollars.

Improving Appoquinnimink River and the mouth of the same, Delaware, five thousand dollars.

Improving Smyrna River, Delaware: Continuing improvement, five thousand dollars.

Improving Choptank River, Maryland: Continuing improvement, seven thousand five hundred dollars.

Improving Susquehanna River, Maryland and Pennsylvania: Continuing improvement, four thousand dollars, to be expended above the Philadelphia, Wilmington and Baltimore Railroad Bridge.

Improving Fairlee Creek or Inlet, Maryland: Continuing improvement, five thousand dollars.

Improving Patuxent River, Maryland, continuing improvement, six thousand dollars.

Improving Wicomico River, Maryland, ten thousand dollars.

Improving Manokin River, Maryland, seven thousand five hundred dollars.

Improving Chester River, Maryland, five thousand dollars, from Crumpton to Jones' Landing.

Improving Elk River, Maryland, ten thousand dollars.

Improving North East River, Maryland, two thousand five hundred dollars.

Improving Potomac River at Washington: Continuing improvement, two hundred and eighty thousand dollars, of which twenty thousand dollars, or so much thereof as may be necessary, may be expended on the channel in the Eastern Branch between the navy-yard and Giesborough Point.

Improving Appomattox River, Virginia: Continuing improvement, fifteen thousand dollars.

Improving Chickahominy River, Virginia: Continuing improvement, two thousand five hundred dollars.

Improving James River, Virginia: Continuing improvement, two hundred thousand dollars: *Provided*, That three thousand five hundred dollars of this amount, or so much thereof as may be necessary, may be expended in the discretion of the Secretary of War in removing the bar at the mouth of Turkey Island Creek or Bayou.

Improving Mattaponi River, Virginia: Continuing improvement, three thousand dollars, fifteen hundred dollars of which may be expended above Ayletts.

Improving channel at Mount Vernon: To complete, two thousand five hundred dollars.

Improving Nomini Creek, Virginia: Continuing improvement, five thousand dollars.

Improving Pamunkey River, Virginia Continuing improvement, three thousand dollars.

Improving Rappahannock River, Virginia: Continuing improvement, fifteen thousand dollars.

Improving Staunton River, Virginia: Continuing improvement, eight thousand dollars on the consolidated project.

Improving Urbana Creek: Continuing improvement, three thousand dollars.

Improving York River, Virginia: Continuing improvement, thirty thousand dollars.

Improving by dredging and otherwise the inland water-way from Chincoteague Bay, Virginia to Delaware Bay at or near Lewes, Delaware, to be used from Chincoteague Bay to Delaware Bay: Continuing improvement, fifty thousand dollars, no part of which shall be expended until the right of way is secured free of cost to the United States.

Improving Nansemond River, Virginia: Continuing improvement, ten thousand dollars.

Improving Hampton Creek and Bar, Virginia: To complete improvement ten thousand dollars.

Improving Occoquan Creek, Virginia, ten thousand dollars.

Improving Acquia Creek, Virginia: ten thousand dollars.

Improving Big Sandy River, West Virginia and Kentucky: To complete improvement, thirty-one thousand dollars.

Improving Elk River, West Virginia: Continuing improvement, two thousand five hundred dollars.

Improving Buchannon River, West Virginia: Continuing improvement, one thousand dollars.

Improving Great Kanawha River, West Virginia: Continuing improvement, three hundred thousand dollars.

Improving Guyandotte River, West Virginia: To complete improvement, two thousand dollars.

Improving Little Kanawha River, West Virginia: To complete projected lock and dam, forty thousand dollars, but no toll shall be collected by any person or corporation for this improved navigation, and such right, if any exist, shall be relinquished in a manner satisfactory to the Secretary of War before the expenditure of any of the money herein appropriated for this work.

Improving Gauley River, West Virginia: Continuing improvement, three thousand dollars.

Improving Tug Fork of Big Sandy River, Kentucky and West Virginia: For snagging and the removal of other obstructions, two thousand five hundred dollars.

Improving Levisa Fork of Big Sandy River, Kentucky: For snagging and the removal of other obstructions, two thousand five hundred dollars.

Improving Cheat River, West Virginia: To complete improvement, thirteen thousand dollars.

Improving Cape Fear River, North Carolina, above Wilmington: Continuing improvement, fifteen thousand dollars.

Improving Cape Fear River at and below Wilmington, North Carolina, one hundred and seventy thousand dollars.

Improving Contentnia Creek, North Carolina: Continuing improvement, seven thousand dollars.

Improving inland water route from Norfolk Harbor, Virginia, to Albemarle Sound, North Carolina, through Currituck Sound: Continuing improvement, ten thousand dollars.

Improving Neuse River, up to Smithfield, North Carolina: Continuing improvement, twenty thousand dollars.

Improving New River, North Carolina: Continuing improvement, five thousand dollars.

Improving Pamlico and Tar Rivers, including the Tar River from Tarboro to Little Falls, North Carolina: Continuing improvement, ten thousand dollars.

Improving Trent River, North Carolina: Continuing improvement, five thousand dollars.

Improving Lumber River, North Carolina and South Carolina: Continuing improvement, five thousand dollars.

Improving Roanoke River, North Carolina: Continuing improvement, from its mouth to Clarksville, twenty-five thousand dollars.

Improving Yadkin River, North Carolina, up to Bailey's Ferry, North Carolina: Continuing improvement, five thousand dollars.

Improving Ocracoke Inlet, North Carolina, ninety thousand dollars.

Improving Mackey's Creek, North Carolina, fifteen thousand dollars to complete the project for nine feet depth of channel.

Improving North East (Cape Fear) River, North Carolina, so far as to clear out its natural obstructions from Wilmington up to Kornegay's Bridge, five thousand dollars.

Improving water way between New River and Swansboro, North Carolina, five thousand dollars.

Improving Lockwood's Folly River, North Carolina, five thousand dollars.

Improving Fishing Creek, North Carolina, from its month to Bellamy's Mill, so far as to remove its natural obstructions, ten thousand dollars: *Provided*, That no part of this sum shall be expended until the bridges over that part of said river to be improved have been removed or suitable draws have been provided in the same, so as not to obstruct the navigation of said river.

Improving Pasquotank River, North Carolina, three thousand dollars.

Improving Edisto River, South Carolina: Continuing improvement, five thousand dollars, which shall be expended in equal sums in the north and south forks of said river.

Improving Great Pee Dee River, South Carolina: Continuing improvement, twelve thousand five hundred dollars.

Improving Salkiehatchie River, South Carolina: To complete existing project, five thousand dollars.

Improving Santee River, South Carolina: Continuing improvement, thirty thousand dollars, to be used in snagging and in making new cut between Estherville and Minim Creek, as recommended by the engineer in charge of the improvement of said river.

Improving Waccamaw River to Waccamaw Lake, North Carolina and South Carolina: Continuing improvement, twelve thousand five hundred dollars.

Improving Wappoo Cut, South Carolina: Continuing improvement, ten thousand dollars.

Improving Wateree River, South Carolina: Completing improvement, twelve thousand five hundred dollars: *Provided*, That no part of said appropriation shall be expended until the Wilmington, Columbia and Augusta Railroad Company and the Camden branch of the South Carolina Railway Company shall have built suitable draw-spans in their bridges over said river, to be approved by the Secretary of War.

Improving Congaree River, South Carolina: Continuing improvement, five thousand dollars: *Provided*, That no part of said appropriation shall be expended until the South Carolina Railroad Company have built a suitable draw-span in its bridge over said river, to be approved by the Secretary of War.

Improving Mingo Creek, South Carolina: Continuing improvement, five thousand dollars.

Improving Clark's River, South Carolina: Continuing improvement, two thousand five hundred dollars.

Improving Little Pee Dee River, South Carolina: Continuing improvement, five thousand dollars.

Improving Beaufort River, South Carolina, or that part of it known as Brickyard Creek, at the point called Brickyard, near Coosaw Mouth, twelve thousand five hundred dollars.

Improving Altamaha River, Georgia, Continuing improvement, fifteen thousand dollars.

Improving Chattahoochee River, Georgia and Alabama: Continuing improvement twenty thousand dollars.

Improving the Coosa River in Georgia and Alabama, between Rome, in Georgia, and the East Tennessee, Virginia and Georgia Railroad Bridge, in Alabama: Continuing improvement under approved existing project, one hundred and fifty thousand dollars. Also for improving said river between Wetumpka, in Alabama, and said East Tennessee, Virginia and Georgia Railroad Bridge, work to be commenced at Wetumpka end, one hundred and fifty thousand dollars, of which so much as may be necessary is authorized to be expended in acquiring, by purchase or condemnation under the laws of Alabama, the lands needed in making such improvement, as the same become necessary; such improvement to be made in harmony with the existing approved project for the improvement of the Coosa River between Rome and said bridge; locks to be forty feet wide and two hundred and ten feet between miter sills.

Improving Flint River, Georgia, Continuing improvement, twenty thousand dollars, of which five thousand dollars are to be expended between Albany and Montezuma, and fifteen thousand below Albany.

Improving Ocmulgee River, Georgia: Continuing and extending improvement, thirty thousand dollars, of which fifteen thousand dollars are to be expended between Macon and Hawkinsville and fifteen thousand dollars between Hawkinsville and its mouth.

Improving Oconee River Georgia: Continuing and extending improvement, twenty-five thousand dollars, of which five thousand dollars are to be expended between Milledgeville and the Central Railroad Bridge.

Improving the Savannah River, between Augusta and Savannah: Continuing improvement, twenty-five thousand dollars.

Improving Jekyl Creek, Georgia: Continuing improvement, seven thousand five hundred dollars.

Improving Apalachicola River, Florida: To maintain existing works, including Lee's Slough, two thousand dollars.

Improving Choctawhatchie River, Florida and Alabama: Continuing improvement under existing projects, and to secure low-water navigation between Geneva and Newton, twelve thousand five hundred dollars: *Provided*, That no part of said sum shall be expended above Hollis's Bridge until a draw, approved by the Secretary of War, is put in said bridge.

Improving Escambia and Conecuh Rivers, Florida and Alabama: Continuing improvement seven thousand five hundred dollars.

Improving Manatee River, Florida: Continuing improvement, six thousand dollars.

Improving Saint John's River, Florida, from Jacksonville to the ocean, including the channel over the bar at the mouth: Continuing improvement, one hundred and seventy thousand dollars.

Improving Suwanee River, Florida: Continuing improvement, three thousand dollars, a part of which may be expended on the inside channel to Cedar Keys.

Improving Volusia Bar, Florida: For repairs, five hundred dollars.

Improving Withlacoochee River, Florida: Completing improvement, five thousand four hundred dollars.

Improving Caloosahatchee River, Florida: To complete improvement, three thousand six hundred dollars.

Improving La Grange Bayou, Florida: Continuing improvement of Holmes River, three thousand dollars.

Improving Ocklawaha River, Florida, to Leesburgh on Lake Griffin, ten thousand dollars.

Improving Sarasota Bay, from Tampa Bay to Sarasota, Florida, as recommended by W. M. Black, captain of engineers, in his report of November twenty-seventh, eighteen hundred and eighty-nine, five thousand dollars.

Improving Alabama River, Alabama: Continuing improvement, twenty thousand dollars.

Improving Black Warrior River, Alabama, from Tuscaloosa to Daniel's Creek: Continuing improvement, one hundred and fifty thousand dollars.

Improving Tallapoosa River, Alabama: Maintaining existing works, four thousand dollars.

Improving Cahawba River, Alabama: The existing provision restricting the expenditure of the balance now available for the improvement of said river is hereby repealed, and said balance shall be expended in continuing the improvement thereof.

Improving Tombigbee and Warrior Rivers, Alabama: Extending improvement so as to secure six feet draught at low water, from the mouth of Tombigbee River to Tuscaloosa, Alabama, one hundred thousand dollars, of which fifty-five thousand dollars to be expended on the Tombigbee and forty-five thousand dollars on the Warrior; so much of said sums as may be necessary is authorized to be expended in acquiring by purchase or condemnation under the laws of Alabama, the lands needed in making such improvements.

Improving Tombigbee River from Demopolis, Alabama, to Columbus, Mississippi: Extending improvement to secure six feet draught at low water, fifteen thousand dollars.

Improving Tombigbee River from Walker's Bridge to Fulton: Continuing improvement, four thousand dollars.

Improving Tombigbee River from Fulton to Vienna: Continuing improvement, six thousand dollars.

Improving Big Sunflower River Mississippi: Continuing improvement, five thousand dollars, of which one thousand five hundred dollars is to be used between Woodburn and Lehrton.

Improving Noxubee River, Mississippi: Continuing improvement, three thousand dollars.

Improving Pascagoula River, Mississippi: Continuing improvement, twenty thousand dollars.

Improving Pearl River, Mississippi, between Edinburgh and Carthage: To complete improvement, five thousand dollars.

Improving Pearl River, Mississippi, between Carthage and Jackson: Continuing improvement, three thousand dollars.

Improving Pearl River, Mississippi, below Jackson: Continuing improvement, twenty thousand dollars, five thousand dollars of which shall be used for dredging at the mouth.

Improving Steele's Bayou, Mississippi, including Washington Bayou: Continuing improvement, two thousand five hundred dollars.

Improving Tallahatchie River, Mississippi: Continuing improvement, five thousand dollars.

Improving Tchula Lake, Mississippi: Continuing improvement, three thousand dollars.

Improving Yazoo River Mississippi Continuing improvement, twenty-five thousand dollars, of which five thousand dollars, or so much as may be necessary, shall be used in making a survey of the Yazoo River from the bridge of the Louisville, New Orleans and Texas Railway to its mouth, for the purpose of determining in what manner the mouth of the river can be so improved as to freely permit the passage through the same, at all seasons of the year, of vessels engaged in the navigation of the river; and said survey shall also include an investigation into the feasibility and advantages of making a new mouth or outlet for said river, by way of Chickasaw Bayou, or otherwise, together with an estimate of the cost of the same.

Improving Bluff Creek, Mississippi: To complete improvement one thousand dollars.

Improving Chickasahay River, Mississippi, by the removal of logs, snags, and overhanging trees, from the mouth up to Railroad Bridge, near Shubuta, five thousand dollars.

Improving Leaf River, Mississippi, from its mouth to the mouth of Bowie Creek, five thousand dollars.

Improving Big Black River, Mississippi: The sum of five thousand dollars, heretofore appropriated for the improvement of this river, may be expended in the improvement of said river, notwithstanding the proviso contained in the act of eighteen hundred and eighty-six making said appropriation.

Improving Amite River and Bayou Manchac, Louisiana: Completion of old project, three thousand eight hundred dollars: *Provided*, That this sum may be expended upon the Manchac or Amite in such proportions as the engineers may deem best.

Improving Boeuf River, Louisiana: Continuing improvement, five thousand dollars.

Improving Bayou Bartholomew, Louisiana and Arkansas: Continuing improvement, five thousand dollars.

Improving Bayou Courtableau, Louisiana: Completing improvement, two thousand two hundred dollars.

Improving Bayou D'Arbonne, Louisiana: Continuing improvement, two thousand dollars.

Improving Tensas River and Bayou Macon, Louisiana: Continuing improvement, five thousand dollars.

Improving Tickfaw River, Louisiana: To complete, one thousand dollars.

Improving Bayous Rondeway and Vidal, Louisiana: Re-opening old bayou, one thousand dollars.

Improving Bayou Plaquemine, Louisiana: Continuing improvement, one hundred thousand dollars.

Improving Bayou Lafourche, Louisiana, including immediate dredging to secure low water navigation, fifty thousand dollars.

Improving Red River, Louisiana and Arkansas, from Fulton, Arkansas, to the Atchafalaya River: Continuing improvement, one hundred thousand dollars, of which fifteen thousand dollars shall be used in the work at Alexandria, twenty thousand dollars in deepening and widening that portion of the river known as Little River, from the Scoping Cut off to Knox Point, and five thousand dollars in closing what is called the Sale and Murphy Outlet, or canal, on the west bank of the river above Shreveport.

For completion of survey of Red River from Fulton, Arkansas, to the Atchafalaya River, Louisiana, twenty eight thousand dollars.

Improving Bayou Teche, Louisiana, from the mouth to Saint Martinsville, five thousand dollars.

Improving Bogue Chitto, Louisiana, five thousand dollars; to be expended from its mouth to where the first bridge obstructing navigation is located.

Improving Tchefuncte and Bogue Phalia: For removal of snags, trees, and obstructions, one thousand dollars.

Improving Buffalo Bayou, Texas: Continuing improvement, twenty-five thousand dollars.

Improving Cedar Bayou, Texas, by removal of bar at the mouth of said bayou, where it empties into Galveston Bay: Completing improvement, eighteen thousand one hundred and fifty dollars.

Improving Trinity River, Texas: Continuing improvement, ten thousand dollars.

The Secretary of War is hereby directed to cause a survey to be made of Cypress Bayou and the lakes between Jefferson, Texas, and Shreveport, Louisiana, in order to ascertain if the navigation of the said bayou and lakes can be materially and perma-

nently improved by the construction of such dams, and locks and dams, as may be necessary, and if found practicable the probable cost thereof, and for this purpose the sum of ten thousand dollars, or so much thereof as may be necessary, is hereby appropriated.

Improving Arkansas River, Arkansas, Indian Territory, and Kansas: Continuing improvement from Wichita, Kansas, to its mouth, one hundred and eighty thousand dollars

Improving Saint Francis River, Arkansas: Continuing improvement, four thousand dollars.

Improving Arkansas River, Arkansas, Indian Territory and Kansas, from Wichita, Kansas, to its mouth: For operating snag-boats and removing obstructions, twenty thousand dollars; and the plant and money now available for operations of this character upon any part of the Arkansas river shall be available for operations under this head; and the Secretary of War is authorized to transfer or sell the heavy steel hull snag-boat now belonging to the plant of the Arkansas river, to the plant of the Missouri or Mississippi river at such charge or price as he may deem just, and said charge or price shall be deducted from the appropriation for the improvement of the river to which this boat may be assigned, and said sum of money shall become available for the improvement of the Arkansas river under the provisions of this clause: *Provided*, That the foregoing transfer or sale shall not be made until the commission having charge of the improvement of the river to which the transfer or sale may be made shall certify to the Secretary of War their approval of the transfer or sale and the terms proposed: *Provided further*, That authority is hereby granted to construct, out of money acquired by the foregoing sale or transfer, a new snag-boat suitable for the present and future wants of the Arkansas river, the same to cost not exceeding twenty thousand dollars.

Improving Red River above Fulton, Arksnsas, to complete, two thousand dollars.

Improving Black River, Arkansas and Missouri: Maintaining existing works, five thousand dollars.

Improving White River, Arkansas: Continuing improvement, thirty thousand dollars.

Improving Fourche River: Completing improvement, seven thousand five hundred dollars.

Improving Ouachita and Black Rivers, Arkansas and Louisiana: Continuing improvement, fifteen thousand dollars.

Improving Big Hatchie River, Tennessee: Continuing improvement five thousand dollars.

Improving Caney Fork River, Tennessee: Continuing improvement, in accordance with last survey, two thousand five hundred dollars.

Improving Clinch River, Tennessee: Continuing improvement, four thousand dollars.

Improving Cumberland River, Tennessee and Kentucky, Continuing improvement above Nashville, two hundred and fifty thousand dollars. *Provided*, That in the discretion of the Secretary of War fifty thousand dollars of this sum may be expended in commencing the improvement of said river at Smith's Shoals.

Improving Cumberland River, Tennessee and Kentucky, below Nashville: Continuing improvement, forty thousand dollars, thirty thousand dollars of which to be used in improving the mouth of the river. The five thousand dollars heretofore appropriated by act of second of August, eighteen hundred and eighty-two, for "improving the Cumberland River above the mouth of Jellico, Kentucky," which said sum of five thousand dollars is yet held over under said act and not expended, be applied to the removal of snags and sand-bars in the said Cumberland River above Nashville, Tennessee, said amount to be thus expended under the direction of the engineer in charge of that work and with the approval of the Secretary of War.

Improving French Broad River, Tennessee: Continuing improvement, ten thousand dollars.

Improving Hiawassee River, Tennessee: To complete improvement, fifteen hundred dollars.

Improving Forked Deer River, Tennessee: Continuing improvement, two thousand five hundred dollars, to be expended on the North Fork from Dyersburgh to the main river, and thence on the main river to its mouth.

Improving Tennessee River above Chattanooga, Tennessee: Continuing improvement, thirty thousand dollars, of which fifteen thousand dollars, or so much thereof as may be necessary, shall be used in making a careful and comprehensive survey of said river from Chattanooga to the junction of the Holston and French Broad Rivers, with a view of ascertaining to what extent the navigation of the river is capable of improvement, and the cost of the same, and the preparation of suitable plans therefor.

Improving Tennessee River, below Chattanooga, Tennessee, including Colbert Shoals and Bee Tree Shoals: Continuing improvement, four hundred and seventy-five thousand dollars, out of which twenty-five thousand dollars may be used at Livingston Point at

the mouth of said river, in accordance with the recommendation of the engineer in charge of that portion of the river.

Improving Kentucky River, Kentucky: Continuing improvement, one hundred and eighty thousand dollars.

Improving the Ohio River: Continuing improvement, three hundred thousand dollars, of which sum seven thousand five hundred dollars shall be expended in constructing an ice-pier pursuant to the present or prospective plan of the Chief of Engineers, at or near the mouth of Kerr's Run, in Ohio: *Provided*, That the Secretary of War is hereby authorized and directed to obtain, if he can do so without cost to the United States, a perpetual lease or conveyance of the riparian rights of the property owners at said locality, in the event said ice-pier shall be located where there is no landing place: *And provided further*, That at said locality, if it be an improved landing, he shall first obtain a relinquishment of wharfage right and dues in favor of water-craft seeking protection from damage by ice; and no part of this appropriation shall be used for such purpose until the foregoing conditions are complied with; and a like sum for like purposes upon similar terms in all respects may be used in the discretion of the engineer in charge of the Ohio River at Ripley, Ohio, and at Portsmouth, Ohio; and twenty thousand dollars of said Ohio River appropriation may be be used for continuation of harbor improvement at Madison, Indiana, according to the plans heretofore submitted by Lieutenant Colonel Merrill; thirteen thousand two hundred and fifty dollars may be expended in the completion of the construction of the embankment on the south side of the Great Miami River near its junction with the Ohio to confine the waters of said Miami River in great floods to the general course of its channel at or near the Ohio, to the end that the formation of the bar in the Ohio now obstructing navigation may be arrested; and fifteen thousand dollars may be expended in completing the embankment at Shawneetown, already partly constructed for the preservation of the harbor at that place; the further sum of twenty thousand dollars may be expended for the removal of rock obstruction at the mouth of Licking River, Kentucky.

Improving the Falls of the Ohio River: Continuing improvement, sixty thousand dollars.

Improving Indiana Chute Fall, Ohio River: Continuing improvement, twenty-five thousand dollars.

Improving Licking River, from Farmer's to West Liberty, Kentucky: Continuing improvement, three thousand dollars.

Improving Rough River, Kentucky, twenty-five thousand dollars; to be expended in procuring the necessary land, commencing the construction of a lock and dam, and removing obstructions in the river from its mouth to Hartford, Kentucky, on the least expensive estimate recommended by Captain James C. Post, Corps of Engineers, in his report of January twenty-seventh, eighteen hundred and eighty-five.

The Secretary of War is hereby authorized and empowed to grant leases or licenses for the use of the water-powers on the Green and Barren Rivers at such a rate and on such conditions and for such periods of time as may seem to him just, equitable, and expedient; said leases not to exceed the period of twenty years: *Provided*, That the leases or licenses shall be limited to the use of the surplus water not required for navigation. And he is also empowered to grant leases or licenses for the occupation of such lands belonging to the United States on said Green and Barren Rivers as may be required for mill-sites or for other purposes not inconsistent with the requirements of navigation; said leases or licenses not to extend beyond the period of twenty years; and all moneys received under such leases or licenses shall be turned into the Treasury of the United States, and the itemized statement thereof shall accompany the annual report of the Chief of Engineers. But nothing in this act shall be construed to affect any vested right, if such there be, of any lessee of water-power on said river.

Improving Sandusky River, Ohio, one thousand five hundred dollars.

Improving Saginaw River, Michigan: Continuing improvement, seventy-five thousand dollars; thirty-seven thousand five hundred dollars of which shall be expended above Bay City.

Improving Saint Mary's River at the Falls, Michigan: Continuing improvement on new locks and approaches, nine hundred thousand dollars: *Provided*, That such contracts as may be desirable may be entered into by the Secretary of War for materials and labor for the entire structure and approaches, or any part of the same, to be paid for as appropriations may from time to time be made by law.

Improving Hay Lake Channel, Michigan: Continuing improvement, four hundred thousand dollars: *Provided*, That such contracts as may be desirable may be entered into by the Secretary of War for materials and labor for the entire work, or any part of the same, to be paid for as appropriations may from time to time be made by law.

Improving Saint Clair Flats Ship-Canal, Michigan: Continuing improvement, eighty thousand dollars.

Improving Clinton River, Michigan: continuing improvement, ten thousand dollars.

Improving Saint Joseph River, Michigan: Completing improvement, one thousand dollars.

Improving mouth of Black River, Michigan: Continuing improvement, ten thousand dollars.

Improving Rouge River, Michigan, at its junction with Detroit River, and up the river as far as the bridge of Saint Louis and Wabash Railroad, ten thousand dollars.

Improving Thunder Bay River, Alpena, Michigan: For sixteen-foot channel from mouth to one mile above, ten thousand dollars.

Improving Black River, at Port Huron, Michigan: To deepen channel from mouth to Grand Trunk Railroad Bridge to depth of sixteen feet, twenty-five thousand dollars.

Improving Menomonee River, Michigan and Wisconsin: Continuing improvement up the river from termination of old work, fifty-four thousand dollars.

Improving Chippewa River including Yellow Banks, Wisconsin: Continuing improvement, ten thousand dollars.

Improving Fox River, Wisconsin, below Portage, except as herein provided: Continuing improvement, one hundred thousand dollars; of this sum five thousand dollars, or so much thereof as may be necessary, shall be used for deepening the south outlet of Lake Winnebago, at Neenah, Wisconsin, so as to make navigation practicable during low-water season; the sum of eight thousand dollars, or so much thereof as may be nececsary, shall be used for removing the sand-bar at outlet of Fon du Lac River, Wisconsin, according to recommendations in report of Major Charles E. L. B. Davis, major of engineers, dated November fourteenth, eighteen hundred and eighty-nine.

Improving Saint Croix River, Wisconsin and Minnesota: Continuing improvement, eight thousand dollars.

Improving Red River of the North, Minnesota: Continuing improvement, twenty-five thousand dollars.

Improving Wabash River, Indiana and Illinois, above Vincennes: Continuing improvement, five thousand five hundred dollars.

Improving Wabash River, Indiana and Illinois, below Vincennes: Continuing the work on lock and dam at Grand Rapids, near Mount Carmel, Illinois, sixty thousand dollars, including snagging; and six thousand dollars of said sum may be expended on said river at or near Grayville in the State of Illinois.

Improving White River, Indiana: The five thousand dollars heretefore appropriated is hereby directed to be expended, notwithstanding the conditions upon which such appropriation was made.

Improving Calumet River, Illinois and Indiana: Continuing improvement, fifty thousand dollars.

That the city of Galena, Illinois, be and hereby is, authorized to continue and complete the improvement and navigation of the channel of Galena River from a point eight hundred feet below the Custom House in said city to the main channel of the Mississippi River upon conditions hereinafter mentioned: *Provided*, That unless said city or her representatives shall commence the work within one year and secure a navigable channel within five years from the approval of this act, the provisions herein shall be null and void.

In carrying out the provisions of this act, the city of Galena or her representatives shall be authorized to construct a dam above the point to be opened for navigation, rising not more than twelve feet above low water or a like dam may be constructed below the point to be opened to navigation with a lock not less than two hundred and eighty feet long and fifty-two feet wide.

In consideration of said improvements the United States promise and agree to pay to the city of Galena, her assigns or legal representatives, the sum of one hundred thousand dollars, when a channel has been opened and maintained for navigation one season to a depth of at least three feet, and of a width sufficient to accommodate any raft or boat that can pass through the lock above described, including sidings or slips, for boats to pass each other, not more than two miles apart.

These improvements though managed and controlled by the city of Galena or her representatives shall be held to belong to the United States and shall be exempt from taxation and no tolls or charges shall be collected, and at the completion of the work, the improved channel with dam and lock shall be turned over to the management, control, and ownership of the United States.

That any person maliciously or intentionally injuring said works or interfering with the construction thereof shall be deemed guilty of a misdemeanor and may be tried for such offense before the District Court of the United States for the district wherein such offense may be committed, and if found guilty, he shall be liable to a fine not exceeding one thousand dollars, or to imprisonment for not more than two years, or to both fine and imprisonment as aforesaid, for each offense.

If the conditions of this act have been complied with, the collector of the Port of Galena and the local Inspectors of steamboats for that District, shall certify to the fact. Upon the receipt of this certificate by the secretary of war he is hereby authorized and directed to draw his warrant on the Treasurer of the United States in favor of the city of Galena, her assigns or legal representatives, in payment of the aforesaid amount: *Provided*, That in no case shall the Government of the United States be liable for any losses or damages incurred by said City of Galena, or its representatives, in the performance of the work herein mentioned, nor shall any payments thereon be made in excess of the sum nor contrary to the terms hereinbefore prescribed.

Improving Illinois River, Illinois: Continuing improvement, two thousand dollars.*

Improving the Kaskaskia River, Illinois, from the mouth to Baldwin Bridge, six thousand dollars.

For the construction of the Illinois and Mississippi Canal to connect the Illinois River at a point near the town of Hennepin with the Mississippi River, at the mouth of Rock River, together with a branch canal or feeder from said Rock River to the main line of said canal, five hundred thousand dollars. Said canal and feeder shall be known as the Illinois and Mississippi Canal, and shall be constructed on the route located by the Secretary of War in pursuance of the provisions of "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," which act became a law August eleventh, eighteen hundred and eighty-eight, and said canal and feeder shall be eighty feet wide at the water line and seven feet deep, the locks one hundred and seventy feet in length and thirty feet in width, and shall have a capacity for vessels of at least two hundred and eighty tons burden, with guard gates, waste-weirs, locks, lock-houses, basins, bridges, and all other erections and fixtures that may be necessary for safe and convenient navigation of said canal and feeders, and shall be constructed on plans and specifications to be approved by the Secretary of War: *Provided*, That the Secretary of War shall, in his discretion, change or alter the dimensions of the locks of said canal and feeder if in his opinion the cost of said improvement is not thereby increased.

It shall be the duty of the Secretary of War, in order to secure the right of way for such canal and feeder, to acquire the title to such lands as may be necessary by agreement, purchase, or voluntary conveyance from the owners, if it can be done on reasonable terms; but if that should be found impracticable, then the Secretary of War shall apply at any term of the circuit or district court of the United States for the northern district of Illinois to be held thereafter, at any general or special term held in said district, and in the name of the United States institute and carry on proceedings to condemn such lands as may be necessary for right of way as aforesaid; and in such proceedings said courts shall be governed by the laws of the State of Illinois, so far as the same may be applicable to the subject of condemning private property for public use; the Secretary of War to cause said work to commence as soon as practicable by the construction of one of the locks and dams on said Rock River at such point as he may deem most advisable, and shall cause said work to be constructed in accordance with the foregoing provisions and of permanent and substantial materials and in a good and workmanlike manner.

For continuing operations upon the reservoirs at the head waters of the Mississippi River, eighty thousand dollars, to be expended in accordance with the recommendations of the Chief of Engineers in his annual report for the year eighteen hundred and eighty-nine.

Improving the Mississippi River above Saint Anthony's Falls: Continuing improvement, eighteen thousand dollars.

Improving the Mississippi from the landing on the west bank below the Washington Avenue Bridge, Minneapolis, to the Des Moines Rapids: Continuing improvement, five hundred thousand dollars, of which sum thirty thousand dollars, or so much thereof as may be necessary, shall be expended by the engineers in charge in removing the sandbars and other obstructions to navigation in the East Channel of the Mississippi River opposite the prairie, on which the city of Prairie du Chien, in the State of Wisconsin, is located, the same being between Minneapolis and Des Moines Rapids; of which sum also fifty thousand dollars shall be expended between the Chicago, Saint Paul, Minneapolis and Omaha Railroad bridge at Saint Paul and the Washington avenue bridge, Minneapolis, in dredging, removal of gravel, bowlders, and broken rock and the construction of dams and revetments; and in the discretion of the Secretary of War, the sum of five thousand dollars, or so much thereof as may be necessary, shall be expended in removing the bar in the river at Port Byron, in the State of Illinois; five thousand dollars at Burlington, Iowa, and two thousand dollars at Montrose, Iowa.

Improving the Mississippi River at Des Moines Rapids Canal: For completion of existing project, twenty-two thousand dollars.

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*See joint resolution approved September 29, 1890, page 3717.

Improving Mississippi River, from Des Moines Rapids to the mouth of the Illinois River, one hundred and sixty-five thousand dollars, out of which twenty-five thousand dollars shall be expended in continuing the dredging in Quincy Bay, in the State of Illinois, and the Secretary of War is authorized and directed to cause an examination and report to be made by a competent engineer upon the advisability of reopening Willow Slough, or some other channel, from the Mississippi River to Quincy Bay; and also fifteen thousand dollars of said sum shall be used in the rectification of the river at Clarksville, Missouri, as suggested in the report of Captain Ruffner; and also twenty-five thousand dollars of said sum, or so much thereof as may be necessary may be expended at the discretion of the Secretary of War to protect the banks of the river from erosion and prevent the destruction of the embankment of the Sny Island levee.

Improving the Mississippi River, from the mouth of the Illinois River to the mouth of the Ohio River, and, at the discretion of the Secretary of War, the protection of the Illinois shore opposite the mouth of the Missouri River, four hundred thousand dollars, fifty thousand dollars of which shall be expended in completing the work at Alton, and fifty thousand dollars in improving the river at Saint Genevieve, in the State of Missouri.

Improving harbor at Saint Louis, Missouri, one hundred and eighty-two thousand dollars.

Improving Mississippi River from the Head of the Passes to the mouth of the Ohio River, including salaries, clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission: Continuing improvement, three million two hundred thousand dollars, which sum shall be expended under the direction of the Secretary of War in accordance with the plans, specifications, and recommendations of the Mississippi River Commission, for the general improvement of the river, for the building of levees, for surveys, including the survey from the head of the Passes to the head waters of the river, for the work at the harbors at Hickman, Kentucky, at New Madrid, Missouri, at Helena, Arkansas, at Greenville, Vicksburg, and Natchez, Mississippi, at New Orleans, Louisiana, at the head of the Atchafalaya and the mouth of the Red River, and at other localities, in such manner, to such extent, and in such proportion as in their opinion shall best promote the interests of commerce and navigation: *Provided*, That the amount expended from such sum for work at the harbors aforesaid shall not exceed six hundred thousand dollars, and the amount expended at the head of the Atchafalaya and the mouth of Red River for the rectification thereof pursuant to the plan heretofore adopted, including keeping open a navigable channel through the mouth of Red or Old River into the Mississippi River shall not exceed two hundred and fifty thousand dollars.

Improving Gasconade River, Missouri: Continuing improvement, four thousand dollars.

Improving Little River, Missouri, from Hornersville to its junction with the Saint Francis River: Completing improvements, three thousand dollars.

Improving Saint Francis River, from Greenville to the Arkansas line: Continuing improvement, ten thousand five hundred dollars; and the Secretary of War is hereby authorized to purchase the Cut-off Canal now owned and controlled by the Dunklin County Transportation Company of Dunklin County, Missouri, if, in his judgment, the interests of commerce require the purchase to be made, and the sum he finds to be reasonable for the purpose may be taken from the money herein appropriated.

Improving the Osage River, Missouri, fifty-five thousand dollars, of which sum five thousand dollars is to be used for snagging and fifty thousand dollars is to be used in commencing the construction of a lock and dam at or near the mouth of said river.

Improving Black River, Missouri: Continuing improvement, seven thousand dollars.

Improving Missouri River from its mouth to Sioux City, Iowa, inclusive, embracing office, clerical, traveling, and other expenses of the Missouri River Commission, surveys, permanent bench-marks, and gauges, eight hundred thousand dollars, to be expended by the Secretary of War in the systematic improvement of the river from its mouth up according to the plans and specification of the Missouri River Commission, to be approved by him in reaches to be designated by them: *Provided*, That in the discretion of the Commission such portion of said sum and of all unexpended balances from former appropriations during the last four years for the improvement of the Missouri River below Sioux City, or any part thereof, not exceeding two hundred and three thousand dollars, as they may deem proper shall be expended in the protection of harbors and localities on any part of the river within said limits.

Improving Missouri River between the foot of the Great Falls of said river in Montana and Sioux City, three hundred thousand dollars, to be expended in the discretion of the Secretary of War, and he is authorized to use so much thereof as may be necessary for the providing of two ice harbors, to be located by him.

Improving Sacramento and Feather Rivers, California: Continuing improvement, thirty thousand dollars.

Improving Napa River, California: Completing improvement, ten thousand dollars.

Improving San Joaquin River, California: Continuing improvement, seventy-five thousand dollars, of which sum twenty-three thousand seven hundred and fifty dollars, or so much thereof as may be necessary, shall be expended in closing Laird's Slough and Paradise Cut, and twenty-four thousand dollars, or so much thereof as may be necessary, shall be expended in dredging, and twenty-seven thousand two hundred and fifty dollars, or so much thereof as may be necessary, shall be expended for cutting off Head Reach.

Improving Pet-a-luma Creek in California: Continuing improvement, four thousand dollars.

Improvement of Redwood Creek, California: To complete dredging, eight thousand dollars.

Improving canal at the Cascades, Oregon: Continuing improvement, four hundred and thirty-five thousand dollars.

Improving Upper Columbia, including Snake River, Oregon and Washington: Continuing improvement, twenty thousand dollars.

Improving the mouth of Columbia River, Oregon: Continuing improvement, four hundred and seventy-five thousand dollars.

Improving Lower Willamette and Columbia Rivers in front and below Portland, Oregon: Continuing improvement, one hundred thousand dollars.

Improving Willamette River above Portland, Oregon, eleven thousand dollars, of which sum five thousand dollars, or so much thereof as may be necessary, may be used, in the discretion of the Secretary of War, for improvement of the river at Clackamas Rapids and Ross Island.

Improving Coquille River, Oregon: Continuing improvement, thirty thousand dollars, not exceeding three thousand dollars of which may, with the approval of the Chief of Engineers, be used for snagging.

Improving Umpqua River, Oregon: To complete, nine thousand dollars.

Improving the mouth of Siuslaw River, in Oregon: To commence construction of jetty, fifty thousand dollars.

Improving Youngs and Klaskuine Rivers, in Oregon: To complete, one thousand six hundred dollars.

Improving Columbia River from the head of Rock Island Rapids to the foot of Priest Rapids, Washington, seventy thousand dollars, of which ten thousand dollars, or so much thereof as may be necessary, may be used in the survey of the Columbia River from the international boundary to Rock Island Rapids.

Improving Chehalis River, Washington: Continuing improvement, three thousand dollars.

Improving Cowlitz River, Washington: Continuing improvement, eight thousand dollars.

Improving Shagit, Stielaquamish, Nootsack, Snohomish, and Snowqualme Rivers, Washington: Continuing improvement, twelve thousand dollars.

The Secretary of War is authorized and directed to appoint a board of three officers of the Corps of Engineers of the United States Army, whose duty it shall be to select and survey the most feasible location, and estimate the expense of construction of a ship-canal to connect the waters of Lakes Union, Washington, and Samamish with Puget Sound; and the sum of ten thousand dollars, or as much thereof as may be necessary, is hereby appropriated for its expenses.

SEC. 2. That nothing contained in section thirty-seven hundred and seventeen of the Revised Statutes of the United States, nor in section three of the river and harbor act of August eleventh, eighteen hundred and eighty-eight, shall be so construed as to prohibit or prevent the cumulation of two or more works of river and harbor improvement in the same proposal and contract, where such works are situated in the same region and of the same kind or character.

SEC. 3. That section five of the river and harbor act of August eleventh, eighteen hundred and eighty-eight, be amended and re-enacted so as to read as follows:

That the Secretary of War be, and is hereby, authorized to make such rules and regulations for the navigation of the South Pass of the Mississippi River as to him shall seem necessary or expedient for the purpose of preventing any obstruction to the channel through said South Pass and any injury to the works therein constructed.

The term "South Pass," as herein employed, shall be construed as embracing the entire extent of channel between the upper ends of the works at the head of the Pass and the outer or sea end of the jetties at the entrance from the Gulf of Mexico; and any willful violation of any rule or regulation made by the Secretary of War in pursuance of this act shall be deemed a misdemeanor, for which the owner or owners, agent or agents, master or pilot of the vessel so offending shall be separately or collectively responsible, and on conviction thereof shall be punished by a fine not exceeding two hun-

dred and fifty dollars or by imprisonment not exceeding three months, at the discretion of the court.

SEC. 4. That section nine of the river and harbor act of August eleventh, eighteen hundred and eighty-eight, be amended and reenacted so as to read as follows:

That whenever the Secretary of War shall have good reason to believe that any railroad or other bridge now constructed, or which may hereafter be constructed over any of the navigable water-ways of the United States is an unreasonable obstruction to the free navigation of such waters on account of insufficient height, width of span, or otherwise, or where there is difficulty in passing the draw-opening or the draw-span of such bridge by rafts, steam boats, or other water-craft, it shall be the duty of the said Secretary, first giving the parties reasonable opportunity to be heard, to give notice to the persons or corporations owning or controlling such bridge so to alter the same as to render navigation through or under it reasonably free, easy, and unobstructed; and in giving such notice he shall specify the changes required to be made, and shall prescribe in each case a reasonable time in which to make them. If at the end of such time the alteration has not been made, the Secretary of War shall forthwith notify the United States district attorney for the district in which such bridge is situated, to the end that the criminal proceedings mentioned in the succeeding section may be taken.

SEC. 5. That section ten of the river and harbor act of August eleven, eighteen hundred and eighty-eight, be amended and re-enacted so as to read as follows:

That if the persons, corporation, or association owning or controlling any railroad or other bridge shall, after receiving notice to that effect as hereinbefore required from the Secretary of War and within the time prescribed by him, willfully fail or refuse to remove the same, or to comply with the lawful order of the Secretary of War in the premises such persons, corporation, or association shall be deemed guilty of a misdemeanor and, on conviction thereof, shall be punished by a fine not exceeding five thousand dollars, and every month such persons, corporation, or association shall remain in default in respect to the removal or alteration of such bridge shall be deemed a new offense, and subject the persons, corporation, or association so offending to the penalties above prescribed.

SEC. 6. That it shall not be lawful to cast, throw, empty, or unlade, or cause, suffer, or procure to be cast, thrown, emptied, or unladen, either from or out of any ship, vessel, lighter, barge, boat, or other craft, or from the shore, pier, wharf, furnace, manufacturing establishments, or mills of any kind whatever, any ballast, stone, slate, gravel, earth, rubbish, wreck, filth, slabs, edgings, sawdust, slag, cinders, ashes, refuse, or other waste of any kind, into any port, road roadstead, harbor, haven, navigable river, or navigable waters of the United States which shall tend to impede or obstruct navigation, or to deposit or place or cause, suffer, or procure to be deposited or placed, any ballast, stone, slate, gravel, earth, rubbish, wreck, filth, slabs, edgings, sawdust, or other waste in any place or situation on the bank of any navigable waters where the same shall be liable to be washed into such navigable waters, either by ordinary or high tides, or by storms or floods, or otherwise, whereby navigation shall or may be impeded or obstructed: *Provided*, That nothing herein contained shall extend or be construed to extend to the casting out, unlading, or throwing out of any ship or vessel, lighter, barge, boat, or other craft, any stones, rocks, bricks, lime, or other materials used, or to be used, in or toward the building, repairing, or keeping in repair any quay, pier, wharf, weir, bridge, building, or other work lawfully erected or to be erected on the banks or sides of any port, harbor, haven, channel, or navigable river, or to the casting out, unlading, or depositing of any material excavated for the improvement of navigable waters, into such places and in such manner as may be deemed by the United States officer supervising said improvement most judicious and practicable and for the best interests of such improvements, or to prevent the depositing of any substance above mentioned under a permit from the Secretary of War, which he is hereby authorized to grant, in any place designated by him where navigation will not be obstructed thereby.

SEC. 7. That it shall not be lawful to build any wharf, pier, dolphin, boom, dam, weir, breakwater, bulkhead, jetty, or structure of any kind outside established harbor-lines, or in any navigable waters of the United States where no harbor-lines are or may be established, without the permission of the Secretary of War, in any port, roadstead, haven, harbor, navigable river, or other waters of the United States, in such manner as shall obstruct or impair navigation, commerce, or anchorage of said waters, and it shall not be lawful hereafter to commence the construction of any bridge, bridge-draw, bridge piers and abutments, causeway or other works over or in any port, road, roadstead, haven, harbor, navigable river, or navigable waters of the United States, under any act of the legislative assembly of any State, until the location and plan of such bridge or other works have been submitted to and approved by the Secretary of War, or to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of the channel of said navigable water of the United States, unless approved and

authorized by the Secretary of War: *Provided*, That this section shall not apply to any bridge, bridge-draw, bridge piers and abutments the construction of which has been heretofore duly authorized by law, or be so construed as to authorize the construction of any bridge, draw bridge, bridge piers and abutments, or other works, under an act of the legislature of any State, over or in any stream, port, roadstead, haven or harbor, or other navigable water not wholly within the limits of such State.

SEC. 8. That all wrecks of vessels and other obstructions to the navigation of any port, roadstead, harbor, or navigable river, or other navigable waters of the Uaited States, which may have been permitted by the owners thereof or the parties by whom they were caused to remain to the injury of commerce and navigation for a longer period than two months, shall be subject to be broken up and removed by the Secretary of War, without liability for any damage to the owners of the same.

SEC. 9. That it shall not be lawful for any person or persons to take possession of or make use for any exclusive purpose, or build upon, alter, deface, destroy, injure, obstruct, or in any other manner impair the usefulness of any sea-wall, bulkhead, jetty, dike, levee, wharf, pier, or other work built by the United States in whole or in part, for the preservation and improvement of any of its navigable waters, or to prevent floods, or as boundary marks, tide-gauges, surveying-stations, buoys, or other established marks, nor remove for ballast or other purposes any stone or other material composing such works.

SEC. 10. That the creation of any obstruction, not affirmatively authorized by law, to the navigable capacity of any waters, in respect of which the United States has jurisdiction, is hereby prohibited. The continuance of any such obstruction, except bridges, piers, docks and wharves, and similar structures erected for business purposes, whether heretofore or hereafter created, shall constitute an offense and each week's continuance of any such obstruction shall be deemed a separate offense. Every person and every corporation which shall be guilty of creating or continuing any such unlawful obstruction in this act mentioned, or who shall violate the provisions of the last four preceding sections of this act, shall be deemed guilty of a misdemeanor, and on conviction thereof shall be punished by a fine not exceeding five thousand dollars, or by imprisonment (in the case of a natural person) not exceeding one year, or by both such punishments, in the discretion of the court, the creating or continuing of any unlawful obstruction in this act mentioned may be prevented and such obstruction may be caused to be removed by the injunction of any circuit court exercising jurisdiction in any district in which such obstruction may be threatened or may exist; and proper proceedings in equity to this end may be instituted under the direction of the Attorney-General of the United States.

SEC. 11. That it shall be the duty of officers and agents having the supervision, on the part of the United States, of the works in progress for the preservation and improvement of said navigable waters, and, in their absence, of the United States collectors of customs and other revenue officers to enforce the provisions of this act by giving information to the district attorney of the United States for the district in which any violation of any provision of this act shall have been committed: *Provided*, That the provisions of this act shall not apply to Torch Lake, Houghton County, Michigan.

SEC. 12. That section twelve of the river and harbor act of August eleventh, eighteen hundred and eighty-eight, be amended and re-enacted so as to read as follows:

Where it is made manifest to the Secretary of War that the establishment of harbor-lines is essential to the preservation and protection of harbors, he may, and is hereby authorized, to cause such lines to be established, beyond which no piers, wharves, bulkheads or other works shall be extended or deposits made, except under such regulations as may be prescribed from time to time by him; and any person who shall willfully violate the provisions of this section, or any rule or regulation made by the Secretary of War in pursuance of this section, shall be deemed guilty of a misdeamor, and, on conviction thereof, shall be punished by a fine not exceeding one thousand dollars, or imprisonment not exceeding one year, at the discretion of the court for each offense.

SEC. 13. That for the purpose of securing the uninterrupted work of operating snagboats on the Ohio River and removing snags, wrecks, and other obstructions in said river, the Secretary of War, upon the application of the Chief of Engineers, is hereby authorized to draw his warrant or requisition from time to time upon the Secretary of the Treasury for such sums as may be necessary to do such work, not to exceed in the aggregate for each year the sum of twenty-five thousand dollars: *Provided, however*, That an itemized statement of said expenses shall accompany the annual report of the Chief of Engineers.

SEC. 14. That the dry dock constructed at the Des Moines Rapids Canal under the provisions of acts of Congress approved August second, eighteen hundred and eighty-two, July fifth, eighteen hundred and eighty-four, August fifth, eighteen hundred and eighty-six, and August eleventh, eighteen hundred and eighty-eight, shall be considered an integrant part of the Des Moines Rapids Canal, and the act of Congress ap-

proved March third, eighteen hundred and eighty-one, which provides for expenses of operating and care of Des Moines Rapids and other canals, and the act of Congress approved July fifth, eighteen hundred and eighty-four, which provides penalties for violation of rules and regulations prescribed by the Secretary of War, shall also apply to the said dry-dock.

SEC. 15. That in determining the mileage of officers of the corps of engineers traveling without troops on duty connected with works under their charge, no deduction shall be made for such travel as may be necessary on free or bond-aided or land-grant railways.

SEC. 16. That whereas the United States, in compliance with its obligation to the Buffalo Bayou Ship-Channel Company, has constructed a ship-channel through Galveston Bay from the Bolivar Channel to the channel constructed by said Buffalo Bayou Ship-Channel Company, known as Morgan's Cut, for vessels of twelve feet draught, it is therefore declared that the ship-channel through Galveston Bay from Bolivar Channel to the point where the San Jacinto River enters what is known as the Morgan Channel, excavated through Morgan's Point, is now the property of the United States and is declared to be free to navigation; and the Secretary of War is hereby directed to keep said ship-channel free to navigation: *Provided*, That the Secretary of War shall first ascertain by a Commission of United States Engineers to be by him designated for that purpose, and whose report shall be subject to his approval, the present value of any portion of said channel which may have been constructed by the Buffalo Bayou Ship Channel Company, agreed to be paid for by the United States in the act of Congress of March third, eighteen hundred and seventy-nine, but in appraising the value thereof no account shall be taken of the charter granted to said Company by the Legislature of Texas, or of any franchise right claimed thereunder, and the amount so ascertained and certified to be correct by the Secretary of War shall be paid to said Buffalo Bayou Ship Channel Company, and is hereby appropriated out of any money in the Treasury not otherwise appropriated.

SEC. 17. That the Secretary of War is hereby directed, at his discretion, to cause examinations or surveys, or both, to be made, and the estimated cost of improvement to be estimated, at the following localities, to wit:

ARKANSAS.

Clarendon and the lower White River, to determine the effect of back water from the Mississippi River and its cause, and the means and cost of preventing injury therefrom.

ARIZONA.

Colorado River above Yuma to Eldorado Canyon, to determine the advisability and probable cost of improving said river.

ALABAMA.

Sucarnochee River, from its mouth to the Mobile and Ohio Railroad Bridge.

Mouth of Gunter's Creek at Guntersville, with the view of ascertaining the practicability and approximate cost of so improving the same as to secure a safe landing above high water mark.

Alabama River, to ascertain cost of securing a six foot channel at low water from mouth to Wetumpka.

CALIFORNIA.

Sacramento and Feather Rivers, to be considered by a board of three United States engineers, with a view to project for future improvement.

San Rafael River.

San Simeon Bay.

Alviso Harbor and straightening, deepening, and improving of Alviso Creek.

Harbor of refuge at Santa Cruz.

Improving and straightening Redwood Creek.

Mokelumne River, for snagging.

Redondo Beach Harbor.

CONNECTICUT.

Connecticut River, from Long Island Sound to Hartford, with a view to such improvement as will keep the channel from shifting its course at certain places.

Shaw's Cove, New London Harbor.

Connecticut River below Hartford.

Saugatuck River.

Stamford Harbor, Stamford.
Cos Cob or Miamus River.
Stony Creek River at Stony Creek.

DELAWARE.

Murderkill River.
Broad Creek River.
Mispillion River, with a view of cutting a canal so as to shorten the distance to the bay, and making an outlet in the bay which would furnish deeper water.

NORTH DAKOTA.

Creel's Bay, Totten Bay, and Minnewauken Shoals, in Devil's Lake, with an estimate of the cost of improving the same by dredging or otherwise, so as to re-establish the navigation of said lake.

NORTH DAKOTA AND MINNESOTA.

Red River of the North, with a view of improving the navigation of the same by the construction of a lock and dam at Goose Rapids in said river.

FLORIDA.

Charlotte Harbor.
Peace River.
Channel lying north and west of the town of Cedar Keys, known as Boat or Number Four Channel.
Indian River between Titusville and Jupiter Inlet.
Saint John's River, from Jacksonville to Sanford, to obtain an estimate of the cost of deepening the channel so as to secure navigation for ocean steamers, and to report separately the cost of opening the channel of the river in the vicinity of Orange Mills.
The upper part of the Saint John's River from Lake Monroe southward, or in a southerly direction through the river and connecting lakes to the head of steam-boat navigation.
St. Augustine, for improvement of channel so as to make a deep sea channel over the outer and inner bars.

GEORGIA.

Chattahoochee River, Georgia and Alabama, between West Point and Franklin.
The Inside Route between Savannah, Georgia, and Fernandina, Florida, with a view of obtaining a steam-boat channel of seven feet depth at mean low water.
The Inside Route between Doboy and Sopelo, with a view of making the same navigable for sea-going vessels.
Brunswick Outer Bar, to determine the feasibility and cost of deepening the same to twenty-six feet at ordinary high water.
Yellow River from the Railroad Bridge near Covington to the Ocmulgee with a view of obtaining a steam-boat channel of five feet deep at mean low water.

ILLINOIS.

Mississippi River at Warsaw, Illinois, with a view of removing bar.
Slough at Hamilton, with a view to dredging out the same.
Illinois River from La Salle to the Mississippi River, as recommended by Captain W. L. Marshall, corps of engineers, in his report dated March ten, eighteen hundred and ninety, with a vew to ascertaining what lands would be subject to overflow by the construction of a navigable waterway between Lake Michigan and the Mississippi River, but not more than twenty-five thousand dollars of the money appropriated for surveys shall be allotted to this river.

INDIANA.

Wabash River from Terra Haute to La Fayette with a view of removing obstructions of snags and bars and re-establishing the navigation of said river between these cities.
With a view to improving the Ohio River, between the mouth of Green River, in the State of Kentucky, and the city of Evansville, in the State of Indiana, and confining the waters of the first named river within its present channel, and preventing danger to navigation from any changes therein, the Secretary of War is hereby authorized and

directed to make, or cause to be made under his direction a complete survey of the Ohio River between the points named, together with full estimates of any expenditures that may be necessary to prevent any injuries or threatened injuries to its permanent use and navigation.

IDAHO.

The Upper Snake River, between the Huntington Bridge and Seven Devils Mining District in Idaho, with a view of overcoming obstructions to steam-boat navigation.

IOWA.

Mississippi River at and above Clinton, Iowa, with view of removing bars north of Little Rock Island.

KENTUCKY.

Russel's Fork of the Big Sandy River with the view of removing obstructions from the same.

Harbor of Owensboro, Kentucky, on the Ohio River.

Harbor of Smithland, Kentucky.

KENTUCKY AND TENNESSEE.

Mississippi River from high water mark Lake County, Tennessee, to high water mark Fulton County, Kentucky, north and west of Reef Foot Lake to ascertain if navigation of the River may not be improved by restraining the flow of water into said Lake, and adjoining low lands.

Green River, Kentucky, above the mouth of Big Barren River, completing survey with a view of extending slack-water navigation on Green River.

Big Barren River, Kentucky, above Bowling Green, with a view of extending slack-water navigation by additional locks and dams.

LOUISIANA.

Bayou Terre Bonne from Houma to Thibodeaux.

Bayou Black to connect with Terre Bonne.

Berwick's Bay to the Gulf, with a view of obtaining a deeper channel.

Bayou Teche from Saint Martinsville to Port Barre.

Bayou Vermillion, bay and passes.

Bayou Black for connection between Calcasieu Lake and Sabine Lake.

Bayou des Glaises, with a view of clearing the stream of obstructions from the Atchafalaya River to Cottonport.

Mermenton River, including its tributaries and course through Lake Arthur and Grand Lake to the Gulf of Mexico.

Bayou Cocodrie, in Saint Landry Parish.

Cane River, with a view of improving the same by locks and dams for the purpose of giving permanent navigation the year round.

Shoals on Lake Pontchartrain near the Rigolets, known as the "Middle Ground," with a view of dredging a channel ten feet deep and revetting sides of the same.

Bayou Castor.

Bayou Chevreuil and Bayou Tigre from Lake Des Allemands to points near Vacherie, Chigby and Malagay settlements in Saint James Parish for removal of bars and other obstructions to navigation.

MARYLAND.

La Trappe.

Turner's Creek.

Rock Hall Harbor.

Nanticoke River, the northwest fork of the same.

Linchester River.

Patapsco River, from the Craighill channel to the sugar refinery wharves, Curtis Bay.

Susquehanna River, above Havre de Grace.

Broad Creek.

Warwick.

Piscataway Creek.

Saint Leonard's Creek.

Newport Creek, head of Wicomico River, Charles County.
Smith's Creek.
Eastern Branch of the Potomac River, including that portion in District of Columbia.
Saint Jerome Bay.

MASSACHUSETTS.

Canapitsit channel between the island of Cuttyhunk and Neshawana, with a view of deepening the same and clearing the channel from obstructions to navigation.

Menemsha Bite, an outlet into Vineyard Sound on the north shore of the island of Martha's Vineyard, with a view of preventing the closing of said inlet.

Kingston Harbor, with a view to its improvement.

Town River.

Shoals at the mouth of North River, with a view of removing the same and other obstructions.

North River, Salem, from Beverly bridge to the North street bridge.

Mystic River, and the Malden River, a tributary of the Mystic, from the bridge of the Boston and Maine Railroad, eastern division, to the head of navigation on said rivers.

Weymouth Back River.

Essex River.

MAINE.

Kennebec River, from Waterville to steam-boat wharf at Augusta, Maine.

Sullivan Falls, Hancock County, Maine, with a view to its improvement for navigation.

Lubec channel.

Harbor of Bluehill, with especial reference to the removal of the ledges known as Middle Ground, eastern and western.

Penobscot River.

Pepperell Cove, forming the eastern boundary of Portsmouth Lower Harbor.

MICHIGAN.

Sebewaing River, with a view of deepening the channel from the mouth to the village of Sebewaing to the depth of eight feet.

Corsica Shoal, situated at the lower end of Lake Huron, near the entrance to the Saint Claire River, with a view to its removal.

The American channel of the Detroit River, beginning at the western boundary of the city of Detriot, and from thence continuously in American waters to Lake Erie, with a view to deepening said channel to the same depth as has been attained and is contemplated under present plan in the Canadian channel of said river, the said survey to be made in the channel of said river fronting the towns of Springwells, Ecorse, Monquagon, and Brownstown, and the American shore of said river to such a point in Lake Erie as may be necessary to reach a proper depth of water in said lake to correspond with the increased depth of the river contemplated by this bill.

Rouge River, with a view of locating and constructing basin in said river, at a point on the same within four miles of its junction with the Detroit River, convenient for the turning and anchoring of vessels in the same.

Ship-channel twenty feet in depth and of a suitable width in the shallows of the connecting waters of the lakes between Chicago, Duluth, and Buffalo.

Grand River, below Grand Rapids, with a view of determining the existence or non-existence of underlying rock, the hydraulics of the river and the detailed topography of the valley subject to overflow.

Re-survey and re-location of harbor line in Portage Lake, Houghton County, Michigan, in conformity with the provisions of recent law.

MINNESOTA.

Red River and tributaries above Fergus Falls and Crookston, and of Big Stone Lake, with a view to improving navigation thereon by the erection of suitable dams or by such other means as may be deemed best, together with an estimate of the cost.

The Saint Louis River from Grassy Point in Saint Louis Bay to Fond du Lac, or the State line between Minnesota and Wisconsin.

MISSOURI.

Current River, from Van Buren, Missouri, to its mounh.

Missouri River, from the old mouth of the Platte River, Little Point, to a point opposite the city of Leavenworth. Also of the river at the city of Weston, Missouri, with

a view of returning said river to its ancient channel, and the best plan of accomplishing the same.

MONTANA.

Missouri River, between Sioux City and Fort Benton.
Missouri River, between Great Falls and canyon next below Stubbs Ferry.
Tongue River, with a view of determining the practicability and approximate cost of straightening the channel of said river, immediately west of Miles City and north of the Northern Pacific railroad track.
Nebraska and South Dakota, Missouri River from the mouth of the Big Sioux River to the north line of the State of South Dakota.
Yellowstone River, from its mouth to the mouth of Tongue River.
Clark's Fork of the Columbia River (by whatever name called) from the international boundary line to the mouth of the Big Blackfoot River, in the State of Montana.

NEW YORK.

Buttermilk channel and Gowanus Bay channels in New York Harbor, with a view of straightening the same by removing the shoals opposite the southeast side of Governor's Island, protecting the channels by a sea-wall on Governor's Island, and to provide for the full width thereof a uniform depth of twenty-six feet at mean low water throughout these channels along the wharves of Brooklyn from a point opposite Wall Street Ferry to the foot of Bryant Street, Brooklyn.
Bay Ridge channel, with a view of removing the shoal and providing a uniform depth of twenty-three feet at mean low water opposite the Bay Ridge shore to the twenty-three-foot curve in the New York harbor.
Hudson River at Cornwall from the Moodna River, otherwise known as Murderer's Creek, to the channel or deep water of the Hudson River.
Inner Bay near mouth of Saranac River at Plattsburgh, for harbor of refuge.
Sag Harbor, Suffolk County, for breakwater.
Princess Bay, Staten Island, for breakwater.
Peconic River, Suffolk County, and Mattituck Bay, Suffolk County, for breakwater.
From Main channel from Jamaica Bay easterly to Long Beach Inlet, for canal.
Champlin's Creek, in town of Islip.
That the Secretary of War is authorized and directed to appoint a board of three officers of the Corps of Engineers, United States Army, whose duty it will be to thoroughly examine the obstructions to navigation in the Hudson River, between New York City and the State dam at Troy, New York, and report a project and estimate of the cost of widening and deepening said river between New York City and the city of Albany, and also between New York City and the State dam at the city of Troy for the navigation of sea-going vessels drawing twenty feet of water, and also a separate estimate of the expense of improving the river between Coxsackie and the State dam at Troy, to such an extent as to socure a navigable channel twelve feet deep at mean low water. Said board shall accompany their report with a statement as to the usefulness of such improvements and of their relations and value to commerce, and of the advisability of entering upon the same at this time; and the Secretary of War shall transmit said reports to Congress with his own views and those of the Chief of Engineers United States Army thereon, and the expenses of said board shall be paid out of the appropriation made in this act for the improvement of the Hudson River, not to exceed ten thousand dollars.
Boquet River, from mouth on Lake Champlain to Willsborough, New York.
Bronx River.
Port Day above Niagara Falls.
Westchester Creek, Westchester and New York Counties.

NEW JERSEY.

Hackensack River, from below the Newark and New York Railroad Bridge, on Newark Bay, to the town of Hackensack.
Pensauken Creek.
Toms River.
Little Egg Harbor Bay and Inlet including Great Bay with reference to establishing a harbor of refuge.
Sound between Barnegat Bay and Great Egg Harbor Bay.
Shark River.
Goshen Creek.

Cape May City, for breakwater.
Thoroughfare from Cape May to the Great Bay north of Atlantic City.

NORTH CAROLINA.

Water-way from Pungo River to the town of Sladesville.
North-West River up to Moyock.
Drum Inlet.
Water-way between Pamlico River and Bay River.
White Oak River from Roberts' Landing to Collins Crossing.
Harbor of Washington, Pamlico River.

OHIO.

Conneant Harbor.
Grand River between Richmond and the mouth.

OREGON.

Tillamook Bay and Bar.
Alsea Bay and River.
Coos Bay, for improving upper harbor by removal of shoals and in dredging.
The Lower Willamette and Columbia Rivers, with a view of securing twenty-five feet at low water from Portland to the mouth of the Columbia.
The Yamhill River from its mouth to McMinnville, with a view of improving the same by removing snags and other obstructions.
Willamette River, deepening channel on west side of Swan Island, improvement of navigation at Clackamas Rapids and Ross Island and near city of Corvallis.
Lower Columbia River, on south side, between Astoria and Wood's Landing for snagging.
Young's Bay channel from the ship channel of the Columbia River to the head of Young's Bay, a distance of one and one-half miles, with a view to improving the same by dredging, so as to secure a depth of eighteen feet at low tide.
Lewis and Clarke's River, for snagging.
Coquille River, for deepening channel from Coquille City to Myrtle Point to four feet at mean low depth.

PENNSYLVANIA.

Delaware Bay, with a view of determining the best site near the mouth of the same for a National harbor of refuge suitable for deep draught vessels. The examination to be made by a commission of three engineer officers, who will make the examination and submit to the Secretary of War a report thereon with a project and estimate of cost of construction of such a harbor of refuge.
The West Branch of the Susquehanna River in the State of Pennsylvania, in order to ascertain if the navigation of said river can be materially and permanently improved by the construction of embankments or otherwise; such survey also to be made with a view of ascertaining the best practicable method of confining the waters of said river in times of great flood, to the general course of its channel.
Tionesta, from the town of Tionesta, to the village of Balltown, with a view to the improvement and the removal of obstructions.

RHODE ISLAND.

Watch Hill Cove, in Little Narragansett Bay.
Narragansett Bay Channel between Starve Goat Island and the main land, with a view of deepening the same.
Newport Harbor, South of Goat Island, with a view to the removal of the Spit at the south end of the Island.

SOUTH CAROLINA.

Wateree River from Camden to the falls of the Catawba, also of the bend or curve in said river about four miles below Camden between the plantations of Witte and Williams to determine if it is advisable in the interest of navigation to make a cut off across the neck of said bend.
Black River, from Kingstree to its mouth.

TENNESSEE.

Obion River, from its mouth to the crossing of the Louisville and Memphis Railroad in Obion County.

Little Pigeon River from mouth to Sevierville.

Memphis Harbor, especially for the removal of the bar forming opposite the upper part of the city or the prevention of the river bank taking the form that the natural forces are now giving it.

TEXAS.

Brazos River from its mouth to Waco.

Sabine River from where said river empties in Sabine Lake to Sudduth's Bluff, on said Sabine River.

Survey to remove obstructions at mouth of Double Bayou in Chambers County, to remove obstructions.

Colorado River, with a view of removing raft at mouth of same.

Saint Charles Bay, with a view of removing obstructions at mouth of same.

Aransas Bay, to remove Half-Moon reef.

West Galveston Bay, from Christian's Point, with a view of reopening the channel through West Bay.

Trinity River from its mouth to Dallas.

VIRGINIA

Water-way to connect Lynn Haven Bay with Eastern Branch of Elizabeth River.
Potomac Creek.
Chickahominy River, from Holly Landing to Long Bridge.
Tangier Harbor.
Wicomico River.
Nottoway River, from mouth of river to Courtland.
West Neck River, to and beyond Dozier's Bridge.
Western Branch of Elizabeth River.
Upper Machodoc Creek.
Crane's Creek.
Nandua Creek.
Piscataway Creek.

WEST VIRGINIA.

Elk River, with a view of improving the same by locks and dams.

WASHINGTON.

Nooksack River, Skagit, Snohomish, D'Wamish, Black, Puyallup, Nasel, North, Gray's, Deep, Skamakawa, and Crooked Rivers.

Gray's Harbor and Bar, and extending up Chehalis River to Montesano.

Gray's River, for snagging.

Swinomish Slough, with the view of constructing a ship channel through the same, connecting Saratoga Passage Skagit Bay with Padilla Bay, and to report the most suitable and feasible plan for making such improvement, with the cost of the same.

Shoalwater Bay, from and including its entrance, to South Bend, about two miles up the Willapah River, and from said South Bend, about ten miles up said river, to Woodward's Landing, with a view to improving the same for navigation.

Olympia Harbor, from deep water in Budd's Inlet to Fourth Street Bridge in the city of Olympia, and separately from said bridge to the mouth of the Des Chutes River at Tumwater, and to report as to the most practical and convenient channel and the most feasible, economical, and suitable plan for improving the same for navigation by the class of vessels employed on Puget Sound, and also to cause to be made an estimate of the cost of each of such improvements.

Columbia River, from the mouth of Willamette River to the upper limits of the city of Vancouver, with a view of establishing a ship-channel.

For a ship channel between Port Townsend Bay, Puget Sound and Oak Bay.

WISCONSIN.

Allonez Bay at the west end of Lake Superior, also the Nemadji River for a distance of four miles above its mouth, with a view of determining the best method of improving and making them available as a portion of the harbor system of the city of Superior.

Harbor at Hudson, with a view to prevent the city being cut off from the navigable channel of the Saint Croix Lake, as a result of the Government dike now constructed at that point, and with a view to the feasibility of conducting the waters of Willow River past the city of Hudson into the navigable channel of the lake.

VIRGINIA AND MARYLAND.

Potomac River, up to the City of Washington, with the view of removing obstructions and deepening the channel.

SEC. 18. That for examinations, surveys, and contingencies, and for incidental repairs, for which there is no special appropriation, for rivers and harbors two hundred and twenty-five thousand dollars: *Provided*, That no survey shall be made of any harbors or rivers until the Chief of Engineers shall have directed a preliminary examination of the same by the local engineer in charge of the district, or an engineer detail for the purpose and such local or detailed engineer and the division engineer of the locality shall report to said Chief of Engineers whether, in their opinion, said harbor or river is worthy of improvement, and shall state in such report fully and particularly the facts and reasons on which they base such opinions, including the present and prospective demands of commerce; and it shall be the duty of the Chief of Engineers to direct the making of such survey, if, in his opinion, the harbor or river proposed to be surveyed be worthy of improvement by the General Government; and he shall report to the Secretary of War the facts, and what public necessity or convenience may be subserved thereby, together with the full reports of the local engineer: *And Provided further*, That no survey for new works other than those designated by law shall be made and the Government shall not be deemed to have entered upon any project for the construction or improvement of any water-way, harbor, or canal mentioned in this act unless or until the work of construction shall have been actually appropriated for. Said reports of preliminary examinations and surveys shall be made to the House of Representatives, and are hereby ordered to be printed when so made.

Approved, September 19, 1890.

AN ACT to amend an act entitled "An act authorizing the construction of a bridge across the Red River of the North," approved July sixteenth, eighteen hundred and eighty-eight.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section five of the act entitled "An act authorizing the construction of a bridge across the Red River of the North," approved July sixteenth, eighteen hundred and eighty-eight be, and the same hereby is, amended so as to extend the time for completing said bridge to four years from the date of passage of said act, instead of two years as specified therein.

Approved, September 25, 1890.

AN ACT to construct a wagon bridge across the Mississippi River at Hastings, Minnesota.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the city of Hastings, a municipal corporation existing under the laws of the State of Minnesota, be, and is hereby, authorized to construct and maintain, at a point suitable to the interest of navigation, a wagon or a combined wagon and foot bridge across the Mississippi River from a point at or near the foot of Sibley street, in the said city of Hastings, Minnesota, on the west bank to a point at or near the graded road nearly opposite on the east bank: *Provided*, That said bridge shall not interfere with the free navigation of said river beyond what is necessary to carry into effect the rights and privileges hereby granted; and in case of any litigation arising from any obstruction, or alleged obstruction, to the free navigation of said river, or damage resulting from the same, the cause may be tried before the circuit court of the United States in and for any district in which any portion of said bridge or obstruction touches.

SEC. 2. That any bridge built under this act shall be constructed as a high bridge with a channel-span giving a clear width of water-way of not less than three hundred and eighty feet and a clear head room of not less than fifty-five feet above high water mark.

SEC. 3. That any bridge constructed under this act, according to its limitations, shall be a lawful structure, and shall be known as a post-route, and the same is hereby declared to be a post-route, upon which no charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States; and

the United States shall have the right of way for postal telegraph purposes across said bridge. For the passage of all kinds of vehicles, for the transit of all kinds of animals, and for the passage of foot-passengers the said bridge shall be free to the public.

SEC. 4. That the structure herein authorized shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said city shall submit to the Secretary of War for examination and approval a design and drawing of the bridge and a map of the location, giving the topography of the banks of the river, the shore-lines at high and low water, and the soundings, accurately showing the bed of the stream, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are decided by the Secretary of War to be such as will not materially affect the interests of navigation the bridge shall not be commenced or built. And should any change be made in the plan of said bridge during the progress of construction such changes shall be subject to the approval of the Secretary of War. And the said bridge shall be constructed with such aids to the passage of said bridge, in the form of booms, dikes, piers, or other suitable and proper structures for confining the flow of water to a permanent and easily navigated channel, and for the guiding of rafts, steam-boats, and other water craft safely under said bridge, as the Secretary of War shall prescribe and at any time order to be constructed and maintained at the expense of the city of Hastings; and the said structure shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels and other water-craft under said structure; and for the safety of vessels passing at night there shall be displayed on said bridge, from the hours of sunset to sunrise, such lights or other signals as may be prescribed by the Light House Board. And the said structure shall be changed or removed at the cost and expense of the said city of Hastings, from time to time, as Congress may direct, so as to preserve the free and convenient navigation of said river; and the authority to erect and continue said bridge shall be subject to revocation and modification by law when the public good shall, in the judgment of Congress, so require, without any expense or charge to the United States.

SEC. 6. That the right to alter, amend, or repeal this act is hereby expressly reserved.

SEC. 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year, and completed within three years from the date thereof.

Approved, September 25, 1890.

AN ACT to authorize the construction of a bridge across the Mississippi River at Winona, Minnesota.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the city of Winona, in the State of Minnesota, is hereby authorized and empowered to erect, establish, and maintain, or authorize the erection, establishment, and maintenance of a foot and carriage bridge across the Mississippi River at a point suitable to the interests of navigation, from the city of Winona, State of Minnesota, so as to connect with the opposite shore of said river in the State of Wisconsin; that said bridge shall not interfere with the free navigation of said river beyond what is necessary in order to carry into effect the rights and privileges hereby granted; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, the cause may be tried before the circuit court of the United States in and for any district in which any portion of said bridge or obstruction touches. Said bridge shall be constructed to provide for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot passengers, for such reasonable rates of toll as may be fixed from time to time by the Secretary of War.

SEC. 2. That any bridge built under the provisions of this act may, at the option of the city of Winona building the same, be built as a draw-bridge or with unbroken and continuous spans: *Provided*, That if the said bridge shall be built with unbroken and continuous spans it shall have one or more channel-spans, each giving a clear head-room of not less than fifty-five feet above high-water mark, as understood at the point of location, and a clear width of water-way of not less than three hundred and fifty feet, and the clear head room under other than channel-spans may be reduced to ten feet above high-water mark, as understood at the point of location, if the interests of navigation be not affected thereby and the piers of said bridge shall be parallel with the current of said river: *And provided further*, That if any bridge built under the provisions of this act shall be constructed as a draw-bridge the same shall be constructed as a pivot draw-bridge, with a draw over the main channel of the river at an accessible and navigable point, and with spans giving a clear width of water-way of not less than two hundred

feet on each side of the center or pivot pier of the draw, and the next adjoining span or spans to the draw shall give a clear width of water-way of not less than three hundred feet, and the said spans shall give a clear head room of not less than ten feet above extreme high-water mark, and the piers of said bridge shall be parallel with the current of said river where said bridge may be erected: *And provided, also*, That said draw shall be opened promptly, by steam or other reliable mechanical power, upon reasonable signal for the passage of boats, vessels, or other water-craft: *And provided, also*, That if any bridge built under this act be located in the immediate vicinity of the existing railroad bridge, the length of spans required by this act may be so modified as to make clear channel-ways correspond in length and location with the clear channel-ways of said existing bridge: *Provided, however*, That no bridge shall be built under the provisions of this act, except there also be built at the time of the erection of the piers proper sheer-booms or other proper protection to safely guide boats, vessels, and other water-craft through said spans, at the expense of the city of Winona, or of the persons or corporation constructing, owning, or operating the bridge.

SEC. 3. That any bridge constructed under this act and according to its provisions and conditions shall be a lawful structure, over which may be transmitted the mails, troops, and the munitions of war of the United States free of charge; and the United States shall have the right of way for postal telegraph purposes across said bridge.

SEC. 4. That the structure herein authorized shall be built and located under and subject to such regulations for the security of the navigation of said river as the Secretary of War shall prescribe, and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawing of the bridge and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore-lines of high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until the said plans and location of the bridge are decided by the Secretary of War to be such as will not materially affect the interests of navigation, the bridge shall not be commenced or built; and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War; and the said structure shall at all times be so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said structure; and for the safety of vessels passing at night there shall be displayed on said bridge, from the hours of sunset to sunrise, such lights as may be prescribed by the Light-House Board; and the said structure shall be changed or removed, at the cost and expense of the owners thereof, from time to time as Congress may direct, so as to preserve the free and convenient navigation of said river; and the authority to erect and continue said bridge shall be subject to revocation and modification by law when the public good shall in the judgment of Congress so require, without any expense or charge to the United States.

SEC. 5. That the right to alter, amend, or repeal this act is hereby expressly reserved.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date hereof.

Approved, September 25, 1890.

AN ACT to authorize the construction of a bridge across the Savannah River by the Middle Georgia and Atlantic Railway Company.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Middle Georgia and Atlantic Railway Company, a corporation organized under the laws of Georgia, be, and is hereby, authorized to construct and maintain a bridge, and the approaches thereto, over the Savannah River, between the States of Georgia and South Carolina, at such point in the county of Effingham, on the Georgia side of said river, and such opposite point in South Carolina as upon actual survey may be deemed best. Said bridge shall be constructed for the passage of railway trains, and, at the option of the corporation, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot passengers.

SEC. 2. That any bridge built under this act shall be a lawful structure, and shall be recognized and known as a post-route, and shall enjoy all the rights and privileges of other post-roads in the United States, and an equal privilege in the use of said bridge and approaches shall be granted to all railway companies.

SEC. 3. That the bridge shall be so constructed by draw, span, or otherwise that a free and unobstructed passage may be secured to all vessels and other water craft navi-

gating said river. That any bridge constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company shall submit to the Secretary of War, for his examination and approval, the design and drawings of the bridge, piers, and approaches, and a map of the location, giving, for the space of at least one mile above and one mile below the proposed location, the topography of the banks of the river, the shore-lines at high and low water, and the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, and the location of other bridge or bridges, wharves, landings, or ferries, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until said plan and location of the bridge are approved by the Secretary of War, the bridge shall not be built, and after such approval by the Secretary of War the approved plans and designs for the bridge shall not be deviated from or added to, either during the construction or after the completion of the bridge, until the proposed change shall have been submitted to the Secretary of War and received his approval; and the said bridge shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said bridge; and if said bridge be built with a draw said draw shall be opened promptly upon reasonable signal for the passing of boats, and the said company or corporation shall maintain at its own expense, from sunset to sunrise, such lights or other signals on such bridge as the Light House Board shall prescribe; and if at any time the navigation of said river shall in any manner be obstructed or impaired by the bridge authorized by this act to be constructed, the Secretary of War shall have authority, and it shall be his duty, to require said company to alter and change the said bridge, at its own expense, in such manner as may be proper to secure free and complete navigation without impediment; and if, upon reasonable notice to said company to make such change or improvements, the said company fails to do so, the Secretary of War shall have authority to make the same, and all the rights conferred by this act shall be forfeited, and Congress shall have power to do any and all things necessary to secure the free navigation of the river: *Provided*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operations of the same.

SEC. 4. That the right to alter, amend, or repeal this act is hereby expressly reserved.

SEC. 5. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date hereof.

Approved, September 25, 1890.

AN ACT to amend an act entitled "An act to authorize the Cairo and Tennessee River Railroad Company to construct bridges across the Tennessee and Cumberland Rivers." Approved January eighth, Eighteen hundred and eighty-nine.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That an act of Congress approved January eighth, eighteen hundred and eighty-nine entitled "An act to authorize the Cairo and Tennessee River Railroad Company to construct bridges across the Tennessee and Cumberland Rivers" be and the same is hereby, amended by striking out the words "below Aurora" in section one, and inserting in lieu thereof "from Birmingham in Marshall County Kentucky to the" and in lines fourteeen and fifteen section four after the words "Secretary of War" insert "or conform to the existing laws of Congress concerning the building of such bridges across navigable streams;" and in section six, line two, strike out "two" and insert in lieu thereof "three" and in line three strike out "three" and insert in lieu thereof "five."

Approved, September 25, 1890.

AN ACT to authorize the construction of bridges over the Savannah, Ocmulgee, and Oconee Rivers by the Macon and Atlantic Railway Company.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of the United States of America is hereby given to the Macon and Atlantic Railway Company, a corporation incorporated by the laws of the State of Georgia, its successors and assigns, and such other persons as may be associated with it, to construct and maintain a bridge over the Savannah River at a point, by it to be selected, within six miles of the bridge of the Charleston and Savannah Railroad Company over said river in the County of Effingham, over the Ocmulgee

River, within six miles of the month of Tobesofka Creek, in Bibb County, and over the Oconee River, within six miles of Dublin, in Laurens County.

SEC. 2. That the bridges shall be so constructed by draw-span or otherwise that a free and unobstructed passage may be secured to all vessels and other water-craft navigating said river. That any bridges constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company shall submit to the Secretary of War, for his examination and approval, designs and drawings of the bridges, piers, and approaches, and a map of the location, giving, for the space of at least one mile above and one mile below the proposed location, of each bridge the topography of the banks of the rivers, the shorelines at high water and at low water, and the direction and the strength of the currents at all stages, and the soundings, accurately showing the bed of the streams and the location of other bridges, wharves, landings, or ferries, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until said plans and locations of the bridges are approved by the Secretary of War the bridges shall not be built; and after such approval by the Secretary of War the approved plans and designs for the bridges shall not be deviated from or added to, either during the construction or after the completion of the bridges, until the proposed change shall have been submitted to the Secretary of War and received his approval; and the said bridges shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said bridges, and if said bridges or any one of them be built with draws, said draws shall be opened promptly upon reasonable signal for the passage of boats or other craft, and the said company or corporation shall maintain at its own expense, from sunset until sunrise, such lights or other signals on said bridges as the Light-House Board shall prescribe; and if at any time the navigation of said river shall in any manner be obstructed or impaired by the bridges authorized by this act to be constructed the Secretary of War shall have authority, and it shall be his duty, to require said company to alter and change said bridges at its own expense, in such manner as may be proper to secure free and complete navigation without impediment; and if upon reasonable notice to said company, its successors or assigns, to make such change or alteration, the said company fails to do so, the Secretary of War shall have authority to make the same, at the expense of the owner or owners of said bridges; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said rivers, caused or alleged to be caused by said bridges, the case may be brought in the district court of the United States in and for the district in whose jurisdiction any portion of said obstruction or bridge may be: *Provided, also*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers or to exempt these bridges from the operations of the same.

SEC. 3. That any bridges built under this act and subject to its limitations shall be lawful structures, and shall be recognized and known as post-routes, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops and munitions of war of the United States, or passengers or freight than the rate per mile for the transportation over the railroads or public highways leading to said bridges, and they shall enjoy the rights and privileges of other post-roads of the United States. And equal privileges in the use of said bridges shall be granted to all telegraph and telephone companies, and the United States shall have the right of way across said bridges and their approaches for postal-telegraph purposes.

SEC. 4. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in said structures or their removal, at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest requires it, is also expressly reserved.

SEC. 5. That this act shall be null and void if actual construction of the bridges herein authorized be not commenced within one year and completed within three years from the date of the approval of this act.

SEC. 6. That all railroad companies desiring the use of said bridges shall have and be entitled to equal rights and privileges relative to the passage of railroad trains or cars over the same, and over the approaches to the same, upon the payment of a reasonable compensation for such use, and in case the owner or owners of said bridges and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon the rules and conditions to which each shall conform in using said bridges, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

Approved, September 25, 1890.

AN ACT to authorize the Chicago, Henderson, Bowling Green and Chattanooga Railway Company to construct a bridge over Green and Barren Rivers, in the State of Kentucky.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Chicago, Henderson, Bowling Green and Chatanooga Railway Company, organized under an act of the general assembly of the Commonwealth of Kentucky, be, and is hereby, authorized to construct and maintain one or more bridges, and the approaches thereto, over Green River and Barren River, in the State of Kentucky, at such points as said company may deem suitable for the passage of its said road over said rivers. Said bridges shall be constructed to provide for the passage of railway trains and, at the option of the corporation by which they may be built, may be used for the passage of wagons and vehicles of all kinds and for foot passengers.

SEC. 2. That any bridges built under this act and subject to its limitations shall be lawful structures, recognized and known as post-routes, and they shall enjoy the same rights and privileges as other post-roads in the United States. Equal privileges in the use of said bridges shall be granted to all telegraph and telephone companies, and the United States shall have the right of way across said bridges and their approaches for postal-telegraph purposes.

SEC. 3. That all railroad companies desiring the use of said bridges shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same, and over the approaches thereto, upon the payment of a reasonable compensation for such use; and in case the owner or owners of said bridges and the several railroad companies, or any of them desiring such use, shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridges, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

SEC. 4. That any bridges authorized to be constructed under this act shall be built and located under the subject of such regulations for the security of the navigation of said river as the Secretary of War shall prescribe, and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawing of the bridges and a map of the location thereof, and until the said plan and location of the bridges are approved by the Secretary of War the bridges shall not be commenced or built; and should any changes be made in the plan of said bridges during the progress of construction, such changes shall be subject to the approval of the Secretary of War; and said bridges shall be at all times so managed and kept as to offer reasonable and proper means for the passage of vessels through or under them; and to secure the safe passage of vessels at night there shall be displayed on said bridges, from sunset to sunrise, such lights or other signals as may be prescribed by the Light-House Board; and all changes in said bridges required by the Secretary of War at any time, or their entire removal, shall be at the expense of the corporations or persons owning or operating said bridges.

SEC. 5. That the right to alter, amend, or repeal this act is hereby expressly reserved.

SEC. 6. That this act shall be null and void if actual construction of the bridges herein authorized be not commenced within one year and completed within three years from the date hereof.

Approved, September 25, 1890.

AN ACT granting right of way across United States lands in Saint Augustine, Florida.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there be, and hereby is, granted to the Saint Augustine Street Railroad Company, a corporation duly organized under and by virtue of the laws of the State of Florida, a right of way for a street railway, along and across the southern and western sides of the Fort Marion military reservation, in the city of Saint Augustine, State of Florida, between the sea-wall and the city gates, upon such route as may be deemed most practicable by the United States engineer officer in charge of said reservation; also a right of way to be located by said engineer officer along the old road, now called Orange street, in said city, with turn-outs to be authorized by the Secretary of War: *Provided*, That said company so change its route as at present located as to run west on Saint Francis street from Marion street to Charlotte street and thence south on Charlotte street as far as the southern boundary of the Saint Francis Barracks Grounds: *And provided, also*, That the company shall construct the road with a grooved rail, in such manner as shall be approved by the Secretary of War, and that the road shall be built and completed within one year from the passage of this act.

SEC. 2. That the portion of said railway that is to be located on the said reservations

shall consist of one track and be constructed of best material, and shall by said railway company be kept in good repair and of even grade with the surface of the reservations, in order that vehicles can cross it, and it shall be operated only by electric motors or horses.

SEC. 3. That the said tracks on the military reservations shall be removed or the route be changed whenever in the judgment of the Secretary of War the interests of the United States shall require it, and the United States shall have the privilege of using the tracks as a tram-way where they lie on the reservations, and the officers and enlisted men of the United States Army and civil employees under the War Department shall be transported on the cars of the company free of charge when traveling on duty through the city under orders from their respective commanding officers.

Approved, September 26, 1890.

AN ACT to grant to the Mobile and Dauphin Island Railroad and Harbor Company a right to trestle across the shoal water between Cedar Point and Dauphin Island.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Mobile and Dauphin Island Railroad and Harbor Company, a corporation duly organized under a charter granted by the general assembly of the State of Alabama, may extend its line, by means of trestle-work from Cedar Point to Dauphin Island, across the intervening shoal water between Mobile Bay and Mississippi Sound: *Provided*, That said company shall cross Grant's Pass and Pass aux Herons each with a draw-bridge of such width, character, and construction as the Secretary of War shall prescribe: *Provided also*, That each such draw shall be opened promptly, upon reasonable signal, for the passage of boats, and that said company shall maintain at its own expense such lights, from sunset to sunrise, on each such draw as the Light-House Board shall prescribe: *And provided further*, That if the United States shall at any time acquire the absolute and satisfactory title to Grant's Pass, the Secretary of War shall be authorized, upon satisfactory proof to him of such investment of title, and if, in his opinion, the interests of the Government shall not then require a draw-bridge to be constructed or maintained at Pass aux Herons, to relieve said company from building or maintaining said draw-bridge, but said company shall thereupon maintain a draw-bridge at Grant's Pass in all respects as hereinbefore prescribed.

SEC. 2. That said company may lay its track across the east end of Dauphin Island, owned by the Government, as far as Fort Gaines, and may build wharves and piers out to deep water from the riparian front owned by the Government: *Provided*, That before any such track shall be laid or any pier or wharf built the approval of the Secretary of War shall be obtained upon plans and specifications submitted to him: *Provided also*, That if any such track is laid or wharf or pier built the same shall be removed at the expense of said company if the Secretary of War should require such removal: *Provided also*, That the Government may use any such structure when built free of charge or tolls: *And provided further*, That said bridge and the construction and extension of the line from its terminus at Cedar Point across to Dauphin Island, and the terminal facilities at and between Dauphin Island and Cedar Point, where they project into navigable water, shall be built and located under and subject to such regulations for the security of navigation as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawing of such bridge or constructions, and a map of the location, giving for the space of one mile in each direction from the proposed location, the topography of the banks, the shores of Mobile Bay, Gulf of Mexico, Mississippi Sound, or strait connecting Mobile Bay and Mississippi Sound, the shore lines at high and low water, the direction and strength of the current at all stages, and the soundings accurately showing the bed and channel of the pass, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plans and location of the bridge or constructions are approved by the Secretary of War they shall not be built, and should any change be made in the plan of such bridge or constructions during the progress of construction thereof, such change shall be subject to the approval of the Secretary of War.

SEC. 3. That no tramway, track, road-bed, wharf, pier, or other structure shall be built upon the United States military reservation on Dauphin Island without the approval and consent of the Secretary of War, and said structures shall be removed by the parties owning or controlling the same, at their own expense, when the Secretary of War so requires.

SEC. 4. That this act shall be null and void if actual construction of the bridge herein

authorized be not commenced within two years and completed within three years from the date hereof.

SEC. 5. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in said structure, or its removal, is also expressly reserved.

Approved, September 26, 1890.

AN ACT authorizing the construction of a bridge over the Tennessee River at or near Knoxville, Tennessee.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Cherokee Land Company, organized under the laws of the State of Tennessee, be and is hereby, authorized to construct and maintain a bridge and approaches thereto over the Tennessee River at or near the city of Knoxville, Tennessee, in the county of Knox. Said bridge shall be constructed to provide for the passage of railway trains and, at the option of the corporation by which it may be built, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals and for foot-passengers for reasonable rates of toll, to be fixed by said company; and the Secretary of War shall have the right, from time to time, to revise, prescribe, and determine such rates of toll.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known and is hereby declared a post-route, and it shall enjoy the rights and privilege of other post-roads in the United States; and the United States shall have the right of way across said bridge for postal-telegraph purposes; and the said bridge shall be so constructed, either by draw, span, or otherwise, that a free and unobstructed passage-way may be secured to all water-craft navigating said river at the point aforesaid: *Provided*, That if said bridge authorized to be constructed under this act shall be constructed as a draw-bridge, the draw shall be opened promptly upon reasonable signal for the passage of boats or vessels; and said corporation shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe.

SEC. 3. That all street car and electric car companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of their cars over the same and over the approaches thereto upon the payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several electric and street car companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon the hearing of the allegations and proofs of the parties.

SEC. 4. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving, for the space of one mile below and one mile above the proposed location, the high and low water lines upon the banks of the river, the direction and strength of the current at all stages, with the soundings, accurately showing the bed of the stream, and the location of any other bridge or bridges, such map to be sufficiently in detail to enable the Secretary of War to judge of the proper location of said bridge, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built; and should any change be made in the plan of said bridge during the progress of construction, such change shall be submitted to and subject to the approval of the Secretary of War.

SEC. 5. That the right to alter, amend, or repeal this act, or any part thereof, is hereby expressly reserved; and any alterations or changes that may be required by Congress in the bridge constructed under this act shall be made by the corporation owning or controlling the same at its own expense. Furthermore, if the construction of said bridge shall not be commenced within one year and completed within three years after the passage of this act, all privileges conferred hereby, and this act, shall become null and void.

Approved, September 26, 1890.

AN ACT to authorize the construction of a bridge across the Chattahoochee River in in the State of Georgia.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Savannah Americus and Montgomery Railway Company, an organization incorporated under the laws of the State of Georgia, its successors and assigns, to construct and maintain a bridge over the Chattahoochee River in the State of Georgia.

SEC. 2. That said bridge shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object said company or corporation shall submit to the Secretary of War a design and drawings of said bridge, for his examination and approval, and a map of its location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the currents at all stages, and the soundings, reduced to low water, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject, and in all things shall be subject to such rules and regulations as may be prescribed by the Secretary of War; and until said plan and location of said bridge are approved by the Secretary of War said bridge shall not be commenced or built; and should any change be made in the plan of said bridge during the progress of the work of construction, such change shall be subject to the approval of the Secretary of War: *Provided*, That if any bridge built under the provisions of this act shall be made with unbroken and continuous spans, it shall be of such elevation above extreme high water, as understood at the point of location, to the lowest part of the superstructure of the bridge, as the Secretary of War may prescribe, and the spans of said bridge shall also be of such width as may be required by the Secretary of War in the interests of navigation: *Provided, also*, That if any bridge built under this act shall be constructed as a draw-bridge, the same shall be constructed as a pivot draw-bridge, with a draw over the main channel of the river, at an accessible and navigable point, and with spans of such height above extreme high-water mark at the point of location, and of such width, as may be prescribed by the Secretary of War in considering the requirements of navigation: *And provided, also*, That said draw shall be opened promptly, upon reasonable signal, for the passing of boats; and said company or corporation shall maintain at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board may prescribe.

SEC. 3. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States, or passengers or freight passing over said bridge, than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge; and it shall enjoy the rights and privileges of other post-roads in the United States, and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies, and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes: *Provided, also*, That other railroad companies shall have the right to run their cars over said bridge and approaches, upon such just and reasonable terms as may be agre d upon by them and the corporation owning or controlling said bridge, and if the parties can not agree, then the terms shall be determined by the Secretary of War.

SEC. 4. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in said structure, or its removal, at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest requires it, is also expressly reserved.

SEC. 5. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof.

Approved, September 26, 1890.

AN ACT to authorize the construction of a bridge across the Oconee River in the State of Georgia.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Savannah, Americus and Montgomery Railway Company, an organization incorporated under the laws of the State of Georgia, its successors and assigns, to construct and maintain a bridge over the Oconee River in the State of Georgia.

SEC. 2. That the bridge shall be so constructed, by draw, span, or otherwise, that a free and unobstructed passage may be secured to all vessels and other water-craft navi-

gating said river. That any bridge constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company shall submit to the Secretary of War, for his examination and approval, a design with drawings of the bridge, piers, and approaches, and a map of the location, giving, for the space of at least one mile above and one mile below the proposed location, the topography of the banks of the river, the shore-lines at high and low water, and the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, and the location of other bridge or bridges, wharves, landings, or ferries, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built, and after such approval by the Secretary of War the approved plans and designs for the bridge shall not be deviated from or added to, either during the construction or after the completion of the bridge, until the proposed change shall have been submitted to the Secretary of War and received his approval; and the said bridge shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said bridge; and if said bridge be built with a draw, said draw shall be opened promptly, upon reasonable signal, for the passing of boats, and the said company or corporation shall maintain at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe; and if at any time the navigation of said river shall in any manner be obstructed or impaired by the bridge authorized by this act to be constructed the Secretary of War shall have authority, and it shall be his duty, to require said company to alter and change the said bridge, at its own expense, in such manner as may be proper to secure free and complete navigation without impediment.

SEC. 3. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States, or passengers or freight passing over said bridge, than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge; and it shall enjoy the rights and privileges of other post-roads of the United States, and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies, and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes: *Provided, also*, That other railroad companies shall have the right to run their cars over said bridge and approaches, upon such just and reasonable terms as may be agreed upon by them and the corporation owning or controlling said bridge, and if the parties can not agree, then the terms shall be determined by the Secretary of War.

SEC. 4. That the right to alter, amend, or repeal this act is hereby expressly reserved; and the right to require any changes in said structure, or its removal, at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest requires it, is also expressly reserved.

SEC. 5. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof.

Approved, September 26, 1890.

AN ACT for the relief of George M. Wheeler.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the President of the United States be, and is hereby, authorized to nominate and, by and with the advice of the Senate, to appoint Captain George M. Wheeler, United States Army, retired, a major on the retired list of the Army, with the rank and pay of that grade from the twenty-third of July, eighteen hundred and eighty-eight, being the date on which he would have been eligible to promotion but for his retirement as captain on June fifteenth, eighteen hundred and eighty-eight.

Approved, September 27, 1890.

AN ACT authorizing the establishing of a public park in the District of Columbia.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That a tract of land lying on both sides of Rock Creek, beginning at Klingle Ford Bridge, and running northwardly, following the course of said creek, of a width not less at any point than six hundred feet, nor more than twelve hundred feet,

including the bed of the creek, of which not less than two hundred feet shall be on either side of said creek, south of Broad Branch road and Blagden Mill road and of such greater width north of said roads as the commissioners designated in this act may select, shall be secured, as hereinafter set out, and be perpetually dedicated and set apart as a public park or pleasure ground for the benefit and enjoyment of the people of the United States, to be known by the name of Rock Creek Park: *Provided, however*, That the whole tract so to be selected and condemned under the provisions of this act shall not exceed two thousand acres nor the total cost thereof exceed the amount of money herein appropriated.

SEC. 2. That the Chief of Engineers of the United States Army, the Engineer Commissioner of the District of Columbia, and three citizens to be appointed by the President, by and with the advice and consent of the Senate, be, and they are hereby, created a commission to select the land for said park, of the quantity and within the limits aforesaid, and to have the same surveyed by the assistant to the said Engineer Commissioner of the District of Columbia in charge of public highways, which said assistant shall also act as executive officer to the said commission.

SEC. 3. That the said commission shall cause to be made an accurate map of said Rock Creek Park, showing the location, quantity, and character of each parcel of private property to be taken for such purpose, with the names of the respective owners inscribed thereon, which map shall be filed and recorded in the public records of the District of Columbia, and from and after the date of filing said map the several tracts and parcels of land embraced in said Rock Creek Park shall be held as condemned for public uses, and the title thereof vested in the United States, subject to the payment of just compensation, to be determined by said commission, and approved by the President of the United States: *Provided*, That such compensation be accepted by the owner or owners of the several parcels of land.

That if the said commission shall be unable by agreement with the respective owners to purchase all of the land so selected and condemned within thirty days after such condemnation, at the price approved by the President of the United States, it shall, at the expiration of such period of thirty days, make application to the supreme court of the District of Columbia, by petition, at a general or special term, for an assessment of the value of such land as it has been unable to purchase.

Said petition shall contain a particular description of the property selected, and condemned, with the name of the owner or owners thereof, if known, and their residences, as far as the same may be ascertained, together with a copy of the recorded map of the park; and the said court is hereby authorized and required, upon such application, without delay, to notify the owners and occupants of the land, if known, by personal service, and if unknown, by service by publication, and to ascertain and assess the value of the land so selected and condemned, by appointing three competent and disinterested commissioners to appraise the value or values thereof, and to return the appraisement to the court; and when the value or values of such land are thus ascertained, and the President of the United States shall decide the same to be reasonable, said value or values shall be paid to the owner or owners, and the United States shall be deemed to have a valid title to said land; and if in any case the owner or owners of any portion of said land shall refuse or neglect, after the appraisement of the cash value of said lands and improvements, to demand or receive the same from said court, upon depositing the appraised value in said court to the credit of such owner or owners, respectively, the fee-simple shall in like manner be vested in the United States.

SEC. 4. That said court may direct the time and manner in which possession of the property condemned shall be taken or delivered, and may, if necessary, enforce any order or issue any process for giving possession.

SEC. 5. That no delay in making an assessment of compensation, or in taking possession, shall be occasioned by any doubt which may arise as to the ownership of the property, or any part thereof, or as to the interests of the respective owners. In such cases the court shall require a deposit of the money allowed as compensation for the whole property or the part in dispute. In all cases as soon as the said commission shall have paid the compensation assessed, or secured its payment by a deposit of money under the order of the court, possession of the property may be taken. All proceedings hereunder shall be in the name of the United States of America and managed by the commission.

SEC. 6. That the commission having ascertained the cost of the land, including expenses, shall assess such proportion of such cost and expenses upon the lands, lots, and blocks situated in the District of Columbia specially benefited by reason of the location and improvement of said park, as nearly as may be, in proportion to the benefits resulting to such real estate.

If said commission shall find that the real estate in said District directly benefited by reason of the location of the park is not benefited to the full extent of the estimated

cost and expenses, then they shall assess each tract or parcel of land specially benefited to the extent of such benefits as they shall deem the said real estate specially benefited. The commission shall give at least ten days' notice, in one daily newspaper published in the city of Washington, of the time and place of their meeting for the purpose of making such assessment and may adjourn from time to time till the same be completed. In making the asessment the real estate benefited shall be assessed by the description as appears of record in the District on the day of the first meeting; but no error in description shall vitiate the assessment: *Provided*, That the premises are described with substantial accuracy. The commission shall estimate the value of the different parcels of real estate benefited as aforesaid and the amount assessed against each tract or parcel, and enter all in an assessment book. All persons interested may appear and be heard. When the assessment shall be completed it shall be signed by the commission, or a majority (which majority shall have power always to act), and be filed in the office of the clerk of the supreme court of the District of Columbia. The commission shall apply to the court for a confirmation of said assessment, giving at least ten days' notice of the time thereof by publication in one daily newspaper published in the city of Washington, which notice shall state in general terms the subject and the object of the application.

The said court shall have power, after said notice shall have been duly given, to hear and determine all matters connected with said assessment; and may revise, correct, amend, and confirm said assessment, in whole or in part, or order a new assessment, in whole or in part, with or without further notice or on such notice as it shall prescribe; but no order for a new assessment in part, or any partial adverse action, shall hinder or delay confirmation of the residue, or collection of the assessment thereon. Confirmation of any part of the assessment shall make the same a lien on the real estate assessed.

The assessment, when confirmed, shall be divided into four equal installments, and may be paid by any party interested in full or in one, two, three, and four years, on or before which times all shall be payable, with six per centum annual interest on all deferred payments. All payments shall be made to the Treasurer of the United States, who shall keep the account as a separate fund. The orders of the court shall be conclusive evidence of the regularity of all previous proceedings necessary to the validity thereof, and of all matters recited in said orders. The clerk of said court shall keep a record of all proceedings in regard to said assessment and confirmation. The commission shall furnish the said clerk with a duplicate of its assessment book, and in both shall be entered any change made or ordered by the court as to any real estate. Such book filed with the clerk when completed and certified shall be prima facie evidence of all facts recited therein. In case assessments are not paid as aforesaid the book of assessments certified by the clerk of the court shall be delivered to the officer charged by law with the duty of collecting delinquent taxes in the District of Columbia, who shall proceed to collect the same as delinquent real estate taxes are collected. No sale for any installment of assessment shall discharge the real estate from any subsequent installment; and proceedings for subsequent installments shall be as if no default had been made in prior ones.

All money so collected may be paid by the Treasurer on the order of the commission to any persons entitled thereto as compensation for land or services. Such order on the Treasurer shall be signed by a majority of the commission and shall specify fully the purpose for which it is drawn. If the proceeds of assessment exceed the cost of the park the excess shall be used in its improvement, under the direction of the officers named in section eight, if such excess shall not exceed the amount of ten thousand dollars. If it shall exceed that amount that part above ten thousand dollars shall be refunded ratably. Public officers performing any duty hereunder shall be allowed such fees and compensation as they would be entitled to in like cases of collecting taxes. The civilian members of the commission shall be allowed ten dollars per day each for each day of actual service. Deeds made to purchasers at sales for delinquent assessments hereunder shall be prima facie evidence of the right of the purchaser, and any one claiming under him, that the real estate was subject to assessment and directly benefited, and that the assessment was regularly made; that the assessment was not paid; that due advertisement had been made; that the grantee in the deed was the purchaser, or assignee of the purchaser, and that the sale was conducted legally.

Any judgment for the sale of any real estate for unpaid assessments shall be conclusive evidence of its regularly and validity in all collateral proceedings except when the assessment was actually paid, and the judgment shall estop all persons from raising any objection thereto, or to any sale or deed based thereon, which existed at the date of its rendition, and could have been presented as a defense to the application for such judgment.

To pay the expenses of inquiry, survey, assessment, cost of lands taken, and all other necessary expenses incidental thereto, the sum of one million two hundred thousand

dollars, or so much thereof as may be necessary, is hereby appropriated out of any money in the Treasury not otherwise appropriated: *Provided*, That one-half of said sum of one million two hundred thousand dollars, or so much thereof as may be expended, shall be re-imbursed to the Treasury of the United States out of the revenues of the District of Columbia, in four equal annual installments, with interest at the rate of three per centum per annum upon the deferred payments: *And provided further*, That one-half of the sum which shall be annually appropriated and expended for the maintenance and improvement of said lands as a public park shall be charged against and paid out of the revenues of the District of Columbia, in the manner now provided by law in respect to other appropriations for the District of Columbia, and the other half shall be appropriated out of the Treasury of the United States.

SEC. 7. That the public park authorized and established by this act shall be under the joint control of the Commissioners of the District of Columbia and the Chief of Engineers of the United States Army, whose duty it shall be, as soon as practicable, to lay out and prepare roadways and bridle paths, to be used for driving and for horseback riding, respectively, and footways for pedestrians; and whose duty it shall also be to make and publish such regulations as they deem necessary or proper for the care and management of the same. Such regulations shall provide for the preservation from injury or spoliation of all timber, animals, or curiosities within said park, and their retention in their natural condition, as nearly as possible.

Approved, September 27, 1890.

AN ACT to authorize the Texas-Mexican Electric Light and Power Company to erect wires across the Rio Grande River at Eagle Pass, Texas.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Texas-Mexican Electric Light and Power Company, a corporation organized and created under and by virtue of the laws of the State of Texas, be, and is hereby, authorized and empowered to construct, own, maintain, and operate its wires across the Rio Grando River between the city of Eagle Pass, in the State of Texas, and the city of Porfirio Diaz, formerly known as Piedras Negras, in the State of Coahuila, in the Republic of Mexico, at such a point as may be most convenient to said corporation: *Provided*, That said wires shall not interfere with the free navigation of said river, and in case of any litigation arising from an obstruction or alleged obstruction to the free navigation thereof, caused or alleged to be caused by said wires, the case may be tried before the district court of the United States for the western district of Texas: *And provided also*, That Congress reserves the right to withdraw the power and authority conferred by this act in case the free navigation of the river shall at any time be substantially or materially obstructed by said wires, or for any other reason, and to direct the removal of said wires, or necessary modifications thereof, at the cost and expense of the owners of said wires; and Congress may at any time alter, repeal, or amend this act: *And provided further*, That the consent of the Mexican State of Coahuila and of the proper authorities of the Republic of Mexico shall have been obtained before the construction of said wires shall be commenced.

Approved, September 27, 1890.

AN ACT to authorize the Eagle Pass Water Supply Company and the Compania Proveedora de Aguas de Ciudad Porfirio Diaz to connect their water works communications across the Rio Rio Grande River at Eagle Pass, Texas.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Eagle Pass Water Supply Company, a corporation organized and created under and by virtue of the laws of the State of Texas, and the Compania Proveedora de Aguas de Ciudad Porfirio Diaz, created under and by virtue of the laws of the State of Coahuila, one of the States of the Republic of Mexico, be, and are hereby, authorized and empowered to construct, own, maintain, and operate their water connection by tubes, or otherwise, across the Rio Grande River, between the city of Eagle Pass, in the State of Texas, and the city of Porfirio Diaz, formerly known as Piedras Negras, in the State of Coahuila, in the Republic of Mexico, as may be most convenient to said corporations: *Provided*, That said connection shall not interfere with the free navigation of said river; and in case of any litigation arising from an obstruction, or alleged obstruction, to the free navigation thereof, caused, or alleged to be caused, by said connection of their water-pipes or hydraulic connections, the case may be tried before the district court of the United States for the western district of Texas: *And provided, also*, That Congress reserves the right to withdraw the power and authority conferred by this,

act in case the free navigation of the river shall at any time be substantially or materially obstructed by said connections or pipes, or for any other reasons, and to direct the removal of said pipes or connections, or necessary modifications thereof, at the cost and expense of the owners of said pipes or connections, and Congress may at any time alter, repeal, or amend this act: *And provided further*, That the consent of the Mexican State of Coahuila and of the proper authorities of the Republic of Mexico shall have been obtained before the establishment of said pipes and connections

Approved, September 30, 1890.

AN ACT making appropriations to supply deficiencies in the appropriations for the fiscal year ending June thirtieth, eighteen hundred and ninety, and for prior years, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, to supply deficiencies in the appropriations for the fiscal year eighteen hundred and ninety, and for prior years, and for other objects hereinafter stated, namely:

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WAR DEPARTMENT.

MILITARY ESTABLISHMENT.

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For additional pay to officer in charge of public buildings and grounds in Washington, District of Columbia, four hundred and sixteen dollars and ninety-five cents.

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ENGINEER DEPARTMENT.

MISSISSIPPI RIVER COMMISSION: For salaries of the Commission, five thousand six hundred and twenty-five dollars.

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JUDGMENTS COURT OF CLAIMS.

For payment of judgments of the Court of Claims as follows:

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To Patrick Maloney and Andrew Gleason, forty-seven thousand nine hundred and ninety-six dollars and seventy-eight cents.

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FOX AND WISCONSIN RIVERS IMPROVEMENT.

To pay in full the amounts certified by the Attorney General in Senate Executive Documents numbered Forty-two and Ninety-nine, Fifty-first Congress, first session, to be due the several commissioners for services and expenses in ascertaining the flowage damages caused by improvements of the Fox and Wisconsin Rivers, in the State of Wisconsin, as follows:

To Commissioner Joseph C. Burdick, six thousand eight hundred and forty-two dollars and fifty cents;

To Commissioner J. Volney Swetting, four thousand three hundred and forty-seven dollars;

To Commissioner B. L. Cornish, six thousand seven hundred and eighty-five dollars;

To Commissioner Samuel Vincent, three thousand one hundred and five dollars;

To Commissioner J. W. Watson, two thousand eight hundred and forty dollars and fifty cents;

To Commissioner Franklin Bowen, two thousand three hundred and thirty-four dollars and fifty cents;

To Commissioner Otis F. Chase, one thousand six hundred and thirty-three dollars;

To Commissioner William Decker, two thousand four hundred and seventy-two dollars and fifty cents;

To Commissioner W. F. S. Root, two thousand one hundred and sixteen dollars;

To Commissioner George H. Buckstaff, two thousand eight hundred and eighty-six

dollars and fifty cents; in all, thirty-five thousand three hundred and sixty-two dollars and fifty cents.

To pay E. E. Chapin for rent of office for use of the special assistant United States attorney appointed to represent the Government in the Fox and Wisconsin River suits, and the Government commissioners, from June thirtieth, eighteen hundred and eighty-six, and January first, eighteen hundred and ninety, at the rate of two hundred and twenty-five dollars per annum, seven hundred and eighty-seven dollars and fifty cents.

For payment of the judgments and awards rendered against the United States for flowage damages caused by the improvement of the Fox and Wisconsin Rivers, in the State of Wisconsin, under the act approved March third, eighteen hundred and seventy-five, as reported to Congress by the Attorney-General in compliance with Senate resolution of August first, eighteen hundred and ninety, in Senate Executive Document Numbered Two hundred and six, Fifty-first Congress, first session, one hundred and twenty thousand four hundred and two dollars and seventy cents.

And any suit now pending in the courts of the State of Wisconsin brought under the provisions of the "Act to aid in the improvement of the Fox and Wisconsin Rivers in the State of Wisconsin," approved March third, eighteen hundred and seventy-five, to recover from the United States damages for alleged flowage of lands, may be removed for trial into the circuit court of the United States for the eastern district of Wisconsin by either party thereto upon the filing in the court where said suit is pending of a petition for such removal and a bond as now provided by law for the removal of causes. The presentation and filing of said petition and bond shall operate to remove said suit, and thereafter it shall be proceeded with in said circuit court of the United States: *Provided*, That no bond on such removal shall be required of the United States.

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CLAIMS ALLOWED BY THIRD AUDITOR AND SECOND COMPTROLLER.

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WAR DEPARTMENT.

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For geographical surveys west of the one hundredth meridian, six dollars and forty-five cents.

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WAR DEPARTMENT.

CLAIMS ALLOWED BY THE THIRD AUDITOR AND SECOND COMPTROLLER.

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For contingencies of fortifications, two thousand six hundred and eighty-two dollars and thirty-nine cents.

For contingencies of fortifications, to adjust the accounts of John C. Fremont, major-general United States Army, to be credited in his accounts, involving the payment of no money from the Treasury, seventy-four thousand seven hundred and sixty-eight dollars and forty-eight cents.

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For improvement Saint Francis River, Arkansas, thirty-four cents.

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Approved, September 30, 1890.

AN ACT to authorize the Mobile, Jackson and Kansas City Railroad Company to cross certain rivers in the State of Mississippi.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Mobile, Jackson and Kansas City Railroad Company, a corporation duly organized and existing under the laws of the States of Alabama and Mississippi, its successors and assigns, to construct, maintain, and use a bridge or bridges, and approaches thereto, over the Pascagoula River, in the county of Green, in the State of Mississippi, or over the two rivers, the Chickasawhay and the Leaf, which form the Pascagoula, above their junction in the said county of Green, at such point or points as said railroad company may desire or

find most practicable in the final location of its railroad between the city of Mobile, in the State of Alabama, and either or both the city of Jackson and the village of Brandon, in the State of Mississippi, and to construct, maintain, and use a bridge or bridges, and approaches thereto, across the Pearl River in or on the line of the county of Rankin, in said State of Mississippi, at such point or points as the said railroad company may find most practicable and convenient when it shall make the final location of its line of railroad in accordance with the charter to it granted by the State of Mississippi: *Provided*, That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river or rivers as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War for his examination and approval a design and drawings of the bridge and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river or rivers, the shore lines at high and low water, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built: *Provided, also*, That if any such bridge shall be built with unbroken and continuous spans they shall conform in length and height to the requirements of the Secretary of War; and if any such bridge shall be constructed as a draw-bridge the same shall be constructed as a pivot draw-bridge, with a draw over the main channel of the river at an accessible and navigable point, and with spans of such length as the Secretary of War shall prescribe; and said draw shall be opened promptly upon reasonable signal for the passage of any kind of river craft, including rafts; and, whatever kind of bridge is built, the said company or corporation shall maintain at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board may prescribe: *And provided, also*, That if more than one bridge is built under this act the above provisions and requirements shall apply to all.

SEC. 2. That any and all bridges built under this act shall be lawful structures, and the line of railroad and bridges so constructed by the said railroad company shall constitute a post-route and shall enjoy all the rights and privileges of other post-roads of the United States.

SEC. 3. That this act shall be null and void if actual construction of the bridges herein authorized be not commenced within two years and completed within four years from the date of the approval of this act.

SEC. 4. That the right to alter, amend, or repeal this act is hereby expressly reserved.

Approved, September 30, 1890.

AN ACT authorizing the use of the Louisville and Portland Canal Basin on certain conditions.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the written contract by and between the city of Louisville, the Louisville and Portland Canal Company, and John P. Byrne, made in the year eighteen hundred and seventy, under which the firm of Byrne and Speed, of Louisville, Kentucky, constructed a basin on the south side of the Louisville and Portland Canal, above Fifteenth street, and also erected buildings, with elevator machinery therein, on land then the property of the Louisville and Portland Canal Company, now the property of the United States, is ratified and confirmed, subject, however, to the following modifications and provisions, to wit: Byrne and Speed, their assignees and grantees, are hereafter to pay to the United States of America, for the use of the land, an annual rental of two hundred and fifty dollars, to be paid semi-annually, through the officer in charge of the canal.

They shall not erect any additional buildings of any kind, but may keep in repair those now standing, or may reconstruct them or any part thereof, in case of destruction by fire or from other cause.

SEC. 2. That when, in the opinion of the Secretary of War, the use of said basin or buildings shall become prejudicial to the canal or its use, he shall detail a commission of not less than three nor more than five officers of the Engineer Corps of the United States Army, with orders to assemble in Louisville, and to decide whether the use of the said basin or buildings is prejudicial to the canal or its use.

Said commission shall cause notice to be given to Byrne and Speed, or their assigns, of the time and place of their sitting, and shall, after hearing any evidence offered by Byrne and Speed, or by the officer representing the Government, proceed to hear and determine the matter submitted to them, and if they find that the use of the said basin or buildings is prejudicial to the canal or its use, they will also assess and find the value of the excavation and masonry of the basin made and erected by Byrne and Speed in the

construction of said basin, and upon the payment or tender by the Secretary of War of the sum so fixed Byrne and Speed shall remove within six months their buildings from the canal property, discontinue the use of said basin, and relinquish all claims under the above mentioned contract.

A copy of the finding of the commission shall be furnished to Byrne and Speed, or their assigns.

SEC. 3. That the ratification provided in this act shall not take effect unless within ninety days from its passage Byrne and Speed shall file with the Secretary of War their written acceptance of its provisions, and in the event Byrne and Speed, or their assigns, shall at any time fail for the space of six months to pay any installment of rent due under this act their right to occupy the property herein mentioned shall at once cease.

Approved, September 30, 1890.

AN ACT to authorize the Canaveral and South Florida Railroad Company to construct and maintain a bridge across the Indian River and one across the Banana River, both in the State of Florida, and to establish the same, in each case, as a post-road.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Canaveral and South Florida Railroad Company, a corporation organized and existing under the laws of the State of Florida, its successors and assigns, be, and is hereby, authorized to construct and maintain a bridge across the Indian River, and also one across the Banana River, in each case at a place suitable to commerce and not interfering with navigation, at such point as may be approved by the Secretary of War, and to lay on or over said bridges a track or tracks for the more perfect connection of any railroad or railroads that are or shall be constructed to said rivers on either or both sides thereof, at or opposite said points, under the limitations and conditions hereinafter provided. Said bridges shall not interfere with the free navigation of said rivers, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said rivers by reason of the construction of said bridges the cause may be tried before the circuit court of the United States in and for any district in whose jurisdiction any portion of said obstruction or bridges may be. Said bridges shall be constructed to provide for the passage of railroad trains, and, at the option of the said company or corporation, its successors and assigns, for the safe and convenient passage of wagons and vehicles of all kinds, animals and foot-passengers, for such reasonable rates of toll as may be fixed from time to time by the Secretary of War.

SEC. 2. That each of said bridges shall be provided with two or more draw-openings, each having not less than two hundred feet clear channel-way, and, in addition to said draw-openings, one or more fixed channel-spans, each having not less than three hundred and fifty feet clear channel-way; and every part of the superstructure of said bridges shall give a clear head room of not less than ten feet above extreme high-water mark: *Provided*, That all spans shall be so located as to afford the greatest possible accommodation to the river traffic, and a draw-opening shall, if practicable, be located next or near shore: *Provided, also*, That if the physical characteristics of the locality so require, and the interests of navigation be not injured thereby, the lengths of the fixed spans or the number of draw-openings may be reduced: *Provided, also*, That for any two adjacent draw-openings of two hundred feet each one draw-opening of three hundred feet may be substituted if, in the opinion of the Secretary of War, the interests of navigation be not injured thereby.

SEC. 3. That all draw-spans authorized by this act shall be operated by steam or other reliable mechanical power, and shall be opened promptly upon reasonable signal for the passage of boats, except when trains are passing over said span or spans; but in no case shall unnecessary delay occur in opening said draw after the passage of trains; and also, that in case the opening of a draw is delayed by reason of the passing of a train after the signal has been given from a boat ready to pass through, the draw shall be opened for the passage of such boat before another train is allowed to pass over the said span or spans; nor shall there be any unnecessary delay in the passage of trains over the bridges.

SEC. 4. That all piers shall be built parallel with the current of the river at that stage of water which is most important for navigation; and the bridges themselves shall be built as nearly as may be at right angles thereto; and that riprapping or other protection for imperfect foundations which will lessen the required water-way shall not be permitted; and also that piers which will produce cross-currents or bars dangerous to navigation shall not be constructed; and if after construction any piers or accessory works are found to produce the above-mentioned effects, or if any riprapping or other protection prohibited by this section is found to exist, the nuisance shall be abated or corrected

under the direction of the Secretary of War, and at the expense of the company or persons owning, controlling, or operating said bridges.

SEC. 5. That the approaches to said bridges shall be so designed and constructed as not to interfere with the free discharge of said river in seasons of flood; and any encroachment on the high-water cross-section by piers, solid embankments, or otherwise which will result in unduly accelerating the high-water current at the site of the bridges shall not be allowed.

SEC. 6. That any corporation, company, or persons owning, controlling, or operating the bridges built under the authority of this act shall build and maintain at all times, as accessory works to such bridges, such booms, piers, dikes, guard-fences, and similar devices as may be necessary to insure at all times a permanent channel for a sufficient distance above and below the bridge sites, and for the guiding of rafts, steam-boats, and other water-craft safely under or through said bridges; and if at any time after the construction of the bridges and their accessory works the approaches to draw-openings, channel-spans, or raft passages in said bridges are found to be dangerous or difficult of access by any important class of river traffic the Secretary of War may, upon the recommendation of the Chief of Engineers, United States Army, order the corporation, company, or persons owning, controlling, or operating said bridges to construct under his directions and to maintain such additional sheer-booms, dikes, and other devices as will obviate the difficulty mentioned, which additional sheer-booms, dikes, and other devices shall be built and maintained at their own expense by said company or persons; and that said company or persons shall maintain at their own expense, from sunset to sunrise throughout the season of navigation, such lights and other signals on said bridges as may be required by the Light-House Board for the security of navigation.

SEC. 7. That the bridges authorized to be constructed by this act shall be located and built under and subject to such regulations for the security of navigation of said rivers as the Secretary of War shall prescribe; and to secure that object said corporation shall submit for his examination a design and drawings of the bridges, piers, approaches, and accessory works, and a map of each location, giving, for a space of at least three miles above and one mile below the proposed locations, the topography of the banks of the rivers and the shore-lines at high and low water. These maps shall be accompanied by others, drawn on the scale of one inch to two hundred feet, giving, for a space of one-half a mile above the line of the proposed bridges and one-quarter of a mile below, an accurate representation of the bottoms of the rivers, by contour lines two feet apart, determined by accurate soundings, and also showing over the whole width of this part of the rivers the force and directions of the currents at low water, at high water, and at least one intermediate stage, by triangulated observations on suitable floats. The maps shall also show the location of other bridges in the vicinity, and shall give such information as the Secretary of War may require for a full and satisfactory understanding of the subject, and the construction of the proposed bridges shall not be commenced until the location and plans thereof are approved by the Secretary of War.

SEC. 8. That any bridges constructed under the authority of this act shall be built under the general supervision of the Secretary of War, and no changes or alterations in plans shall be made during the construction of said bridges or after their completion, unless said changes or alterations conform to the provisions of this act and are authorized by the Secretary of War; that such alterations and changes as may be required by the Secretary of War in said bridges so as to preserve free and convenient navigation shall be made under the direction of the Secretary of War at their own expense by the company or persons owning, controlling, or operating said bridges; that during original construction or in carrying out any authorized changes or repairs of said bridges a navigable channel shall be preserved at the site of the bridges at all times, and the water-way of the river shall not be obstructed to a greater extent than is absolutely necessary; and such lights and buoys shall be kept on all coffer-dams, piles, and so forth, as may be necessary for the security of navigation.

SEC. 9. That whenever the Secretary of War has good reason to believe that any of the provisions of sections four, six, and eight of this act have not been complied with by the company or persons owning, controlling, or operating the bridges authorized under its provisions, it shall be the duty of the Secretary of War, on satisfactory proof thereof, to require the said company or persons to comply with the provisions of said sections; and on failure of said persons or company to comply with said requirements within a reasonable time the Secretary of War shall proceed to cause the necessary work, in the form of additions, alterations, repairs, or removal of obstructions, to be made at the expense of the United States and shall refer the matter, without delay, to the Attorney-General of the United States, whose duty it shall be to institute, in the name of the United States, proceedings in the circuit court of the United States in and for the district in which any portion of said obstructions or bridges may be, for the recovery of such

expense, and all moneys accruing from such proceedings shall be covered into the Treasury of the United States.

SEC. 10. That all railroad companies desiring the use of the bridges authorized by this act shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same, and over the approaches thereto, upon the payment of a reasonable compensation for such use; and in case the owner or owners of said bridges and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridges, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties; and equal privileges in the use of said bridges shall be granted to all telegraph and telephone companies.

SEC. 11. That the bridges constructed, maintained, and operated under this act and according to its limitations shall be lawful structures, and shall be recognized and known in each case as a post-route, upon which also no higher charge shall be made for transportation over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation of said mails, troops, and munitions over the railroads and public highways leading to said bridges; and the United States shall have the right of way for postal telegraph and telephone purposes over said bridges.

SEC. 12. That this act shall be null and void if actual construction of the bridges herein authorized be not commenced within one year and completed within three years from the date of approval thereof.

SEC. 13. That the right to alter, amend, or repeal this act is hereby expressly reserved; and the right to require the entire removal of the bridges constructed under the provisions of this act at the expense of the owners thereof, whenever Congress shall decide that the public interests require it, is also expressly reserved.

Approved, September 30, 1890.

AN ACT to authorize the construction of a bridge across the Kentucky River and its tributaries by the Louisville, Covington and Cincinnati Railway Company, the Carrollton and Louisville Railroad Company, and the Westport, Carrollton and Covington Railway Company and their assigns.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Louisville, Covington and Cincinnati Railway Company, the Carrollton and Louisville Railroad Company, and the Westport, Carrollton and Covington Railway Company, corporations organized under acts of the general assembly of the Commonwealth of Kentucky, their successors and assigns are, authorized to construct and maintain a bridge or bridges, and approaches thereto, over the Kentucky River, in the State of Kentucky, at or near Carrollton, at such a point or points as said companies may deem suitable for the passage of their said road or roads over said river or its tributaries, subject to approval of the Secretary of War. Said bridge or bridges shall be constructed to provide for the passage of railway trains and, at the option of the company or companies by which it or they may be built, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot-passengers.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure and shall be recognized and known as a post-route, and it shall enjoy the rights and privileges of other post-roads in the United States; and equal privileges in the use of said bridge or bridges shall be granted to all telegraph and telephone companies; and the United States shall have the right of way across said bridge or bridges, and approaches, for postal-telegraph purposes.

SEC. 3. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or companies shall submit to the Secretary of War, for his examination and approval, a design and drawing of each bridge, and a map of the location thereof, giving the high and low water lines upon the banks of the river, the direction and strength of the currents at all stages of the water, with soundings accurately showing the bed of the stream, and the location of any other bridge or bridges; such map to be sufficiently in detail to enable the Secretary of War to judge of the proper location of said bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until such plan and location of the bridge or bridges are approved by the Secretary of War, no bridge shall be built or commenced; and should any change be made in the plan of such bridge or bridges during the progress of construction, such change shall be subject to the approval of the Secretary of War; and if

the Secretary of War shall at any time think any changes necessary in the plans of said bridge or bridges, the said alterations shall be at the expense of the company or companies owning the same. The said bridge or bridges shall at all times be so kept and managed as to offer reasonable and proper means for the passage of vessels and other water-craft through or under said structures, and for the safety of vessels passing at night there shall be displayed on said bridge or bridges, from the hours of sunset to sunrise, such lights or other signals as may be prescribed by the Light-House Board.

SEC. 4. That all railroad companies desiring the use of said bridge or bridges shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same, and over the approaches thereto, upon the payment of reasonable compensation therefor; and in case the owner or owners of said bridge or bridges and the company or companies desiring to use the same shall fail to agree upon the terms with reference to the use of the same, all matters at issue between them shall be decided by any court of competent jurisdiction, or by the Seeretary of War, by agreement of the parties interested, upon a hearing of the allegations and proofs of the parties.

SEC. 5. That this act shall be null and void if actual construction of the bridge or bridges herein authorized be not commenced within two and completed within five years from the date thereof.

SEC. 6. That the right to alter, amend, or repeal this act is hereby expressly reserved.

Approved, September 30, 1890.

AN ACT to authorize the building of a bridge at Dardanelle, Arkansas, across the Arkansas River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Cable City Bridge Construction Company, a corporation duly organized and existing under the laws of the State of Missouri, its successors and assigns, be, and are hereby, authorized to construct and maintain a ponton bridge and approaches thereto across the Arkansas River in front of Dardanelle, at a point at least one mile from any other bridge, and which shall not be detrimental to the interest of navigation or of any river improvement. Said bridge shall be constructed so as to provide for the passage of wagons and vehicles of all kinds, animals, and foot-passengers, and for all road travel, for such reasonable rates of toll and under such reasonable rules and regulations as may be prescribed by said corporation, its successors or assigns and approved from time to time by the Secretary of War.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than is charged other parties for like privileges; and it shall enjoy the rights and privileges of other post-roads in the United States, and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes; and equal rights as to constructing and maintaining their lines over said bridge shall be granted to all telegraph and telephone companies desiring to use the same.

SEC. 3. That said bridge shall be constructed as a ponton draw-span bridge, and shall contain a ponton draw-span of not less than three hundred feet in length, which said draw-span shall be maintained on the main channel of the river at an accessible and navigable point; and the piers of said bridge shall be parallel with, and the bridge itself at right angles to, the current of the river: *Provided, also*, That said draw shall be opened promptly by the said company, upon reasonable signal, for the passage of boats and rafts; and said company or corporation shall maintain at their own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe. No bridge shall be constructed or maintained under the authority of this act which shall at any time substantially or materially obstruct the free navigation of said river; and if any bridge erected under said authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction; and all such alterations shall be made and all such obstructions be removed at the expense of the owner or owners of said bridge; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, suit may be brought in the district court of the United States for the western district of the State of Arkansas to remove or remedy the same: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

SEC. 4. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design together with drawings of the said bridge, and a map of the location, giving, for the space of one-half mile below the proposed location, the high and low water lines upon the banks of the river, the direction and strength of the current at all stages, with the soundings, accurately showing the bed of the stream and the location of any other bridge or bridges, such map to be sufficiently in detail to enable the Secretary of War to judge of the proper location of said bridge, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; but should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War.

SEC. 5. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in the said structure, or its entire removal, at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest so requires, is also expressly reserved.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof.

Approved, September 30, 1890.

AN ACT to provide for the examination of certain officers of the Army and to regulate promotions therein.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That hereafter promotion to every grade in the Army below the rank of brigadier-general, throughout each arm, corps, or department of the service, shall, subject to the examination hereinafter provided for, be made according to seniority in the next lower grade of that arm, corps, or department: *Provided*, That in the line of the Army all officers now above the grade of second lieutenant shall, subject to such examination, be entitled to promotion in accordance with existing laws and regulations.

SEC. 2. That officers of grades in each arm of the service shall be assigned to regiments, and transferred from one regiment to another, as the interests of the service may require, by orders from the War Department, and hereafter all appointments in the line of the Army shall be by commission in an arm of the service and not by commission in any particular regiment.

SEC. 3. That the President be, and he is hereby, authorized to prescribe a system of examination of all officers of the Army below the rank of major to determine their fitness for promotion, such an examination to be conducted at such times anterior to the accruing of the right to promotion as may be best for the interests of the service: *Provided*, That the President may waive the examination for promotion to any grade in the case of any officer who in pursuance of existing law has passed a satisfactory examination for such grade prior to the passage of this act: *And provided*, That if any officer fails to pass a satisfactory examination and is reported unfit for promotion, the officer next below him in rank, having passed said examination, shall receive the promotion: *And provided*, That should the officer fail in his physical examination and be found incapacitated for service by reason of physical disability contracted in line of duty he shall be retired with the rank to which his seniority entitled him to be promoted; but if he should fail for any other reason he shall be suspended from promotion for one year, when he shall be re-examined, and in case of failure on such re-examination he shall be honorably discharged with one year's pay from the Army: *And provided further*, That the examination of officers appointed in the Army from civil life, or of officers who were officers of volunteers only, or were officers of the militia of the several States called into the service of the United States, or were enlisted men in the regular or volunteer service, either in the Army, Navy, or Marine Corps, during the war of the rebellion, shall be conducted by boards composed entirely of officers who were appointed from civil life or of officers who were officers of volunteers only during said war, and such examination shall relate to fitness for practical service and not to technical and scientific knowledge; and in case of failure of any such officer in the re-examination hereinbefore provided for, he shall be placed upon the retired list of the Army; and no act now in force shall be so construed as to limit or restrict the retirement of officers as herein provided for.

Approved, October 1, 1890.

AN ACT to amend an act entitled "An act to establish a railway bridge across the Illinois River, extending from a point within five miles of Columbiana, in Greene County, to a point within five miles of Farrowtown, in Calhoun County, in the State of Illinois," approved March third, eighteen hundred and eighty-three.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the first section of said act be, and the same is hereby, amended by inserting after the word "Company," in the third line, the words "a corporation organized under the laws of the State of Illinois;" also by striking out the word "Farrowtown," in the fourth line, after the word "of" and before the word "in," and inserting in lieu thereof the word "Kampsville," so that the said section shall read as follows:

"*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That the Litchfield, Carrollton and Western Railroad Company, a corporation organized under the laws of the State of Illinois, its successors and assigns, are hereby authorized and empowered to erect, establish, and maintain a railway bridge across the Illinois River, within five miles of Columbiana, in Greene County, and within five miles of Kampsville, in Calhoun County, in the State of Illinois, at such point as may be approved by the Secretary of War, and that said bridge shall not interfere with the free navigation of said river, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river the same shall be instituted and determined in the district court of the United States for the southern district of the State of Illinois."

Also that section two of said act be, and the same is hereby, amended by inserting just before the final proviso of said section the words "and the bridge itself shall be built, as nearly as may be, at right angles to the current of the river, at the stage of the river most important for navigation; and no span of said bridge shall be less than one hundred and fifty feet in length, measured at right angles to the current of the river within the limits of the low-water channel of the Illinois River; nor shall the effective discharge area of the river, or navigable channels through the draw-spans, be unduly diminished by rip-rap, piles, or other obstructions placed about the piers of said bridge by said company." So that the second proviso of said section shall read:

And provided also, That if any bridge built under this act shall be constructed as a draw-bridge, the same shall be constructed as a pivot draw-bridge, with a draw over the main channel of the river at an accessible and navigable point, and with spans of not less than one hundred and fifty feet in length in the clear on each side of the central or pivot pier of the draw; and the next adjoining spans to the draw shall not be less than two hundred and fifty feet, and said spans shall not be less than thirty feet above low-water mark, and not less than ten feet above extreme high-water mark, measuring to the bottom chord of the bridge; and the piers of said bridge shall be parallel with the current of the river where said bridge may be erected; and the bridge itself shall be built as nearly as may be at right angles to the current of the river, at the stage of the river most important for navigation; and no span of said bridge shall be less than one hundred and fifty feet in length, measured at right angles to the current of the river, within the limits of the low-water channel of the Illinois River; nor shall the effective discharge area of the river, or navigable channels through the draw-spans be unduly diminished by rip-rap, piles, or other obstructions placed about the piers of said bridge by said company. All the rights in this act granted shall be exercised subject to the approval of the Secretary of War.

SEC. 2. That unless the said bridge shall be commenced within one year and completed within three years from the date of the approval of this act, the rights and privileges hereby granted, as well as those granted by the act approved March third, eighteen hundred and eighty-three, shall cease and be determined.

SEC. 3. The right to amend or repeal this act at the pleasure of Congress is hereby expressly reserved.

Approved, October 1, 1890.

AN ACT to authorize the construction of a bridge across the Alabama River, at or near Selma, Alabama, by the Selma and Cahawba Valley Railroad Company.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Selma and Cahawba Valley Railroad Company, a corporation existing under the laws of Alabama, its successors and assigns, be, and is hereby, authorized to construct and maintain a bridge across the Alabama River at a place suitable to commerce and not interfering with navigation, at a point at or near Selma, in the State of Alabama, and to lay on or over said bridge a track or tracks for the more perfect connection of any railroad or railroads that are or shall be constructed to said river, on either or both sides

thereof, at or opposite said point, under the limitations and conditions hereinafter provided; that said bridge shall not interfere with the free navigation of said river, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, by reason of the construction of said bridge, the cause may be tried before the circuit court of the United States in and for any district in whose jurisdiction any portion of said obstruction or bridge may be. Said bridge shall be constructed to provide for the passage of railroad trains.

SEC 2. That said bridge shall be provided with one or more draw-openings, each having not less than one hundred and twenty-five feet clear channel-way at low water and in addition to said draw-openings one or more fixed channel-spans, each having not less than two hundred feet clear channel-way; and every part of the superstructure of said bridge shall give a clear head room of not less than ten feet above extreme known high-water mark: *Provided*, That all spans shall be so located as to afford the greatest possible accommodation to the river traffic, and a draw opening shall, if practicable, be located next or near shore: *Provided, also*, That if the physical characteristics of the locality so require, and the interests of navigation be not injured thereby, the lengths of the fixed spans or the number of draw-openings may be reduced: *Provided, also*, That for any two adjacent draw-openings of one hundred and twenty-five feet each one draw-opening of two hundred feet or more may be substituted if in the opinion of the Secretary of War the interests of navigation be not injured thereby.

SEC. 3. That all draw-spans authorized by this act shall be operated by steam or other reliable power, and shall be opened promptly upon reasonable signal for the passage of boats, except when trains are passing over said span or spans; but in no case shall unnecessary delay occur in opening said draw after the passage of trains; and also that in case the opening of a draw is delayed by reason of the passing of a train after the signal has been given from a boat ready to pass through the draw shall be opened for the passage of such boat before another train is allowed to pass over the said span or spans; nor shall there be any unnecessary delay in the passage of trains over the bridge.

SEC. 4. That all piers shall be built as near as may be parallel with the current of the river at that stage of water which is most important for navigation, and the bridge itself shall be built as nearly as may be at right angles thereto; and that riprapping or other protection for imperfect foundations which will lessen the required waterway shall not be permitted; and also that piers which will produce cross-currents or bars dangerous to navigation shall not be constructed; and if after construction any piers or accessory works are found to produce the above-mentioned effects, or if any riprapping or other protection prohibited by this section is found to exist, the nuisance shall be abated or corrected under the direction of the Secretary of War, at the expense of the company or persons owning, controlling, or operating said bridge.

SEC. 5. That the approaches to said bridge shall be so designed and constructed as not to interfere with the free discharge of said river in seasons of flood; and any encroachment on the high-water cross-section by piers, solid embankments, or otherwise which will result in unduly accelerating the high-water current at the site of the bridge shall not be allowed.

SEC. 6. That any corporation, company, or persons owning, controlling, or operating the bridge built under the authority of this act shall build and maintain at all times, as accessory works to such bridge, such booms, piers, dikes, guard fences, and similar devices as may be necessary to insure at all times a permanent channel for a sufficient distance above and below the bridge site, and for the guiding of rafts, steam-boats, and other water-craft safely under or through said bridge; and if at any time after the construction of the bridge and its accessory works the approaches to draw openings, channel-spans, or raft-passages in said bridge are found to be dangerous or difficult of access by river traffic, the Secretary of War may, upon the recommendation of the Chief of Engineers, United States Army, order the corporation, company, or persons owning, controlling, or operating said bridge to construct, under his directions, and to maintain such additional sheer-booms, dikes, and other devices as will obviate the difficulty mentioned, which additional sheer-booms, dikes, and other devices shall be built and maintained at their own expense by said company or persons; and that said company or persons shall maintain, at their own expense, from sunset to sunrise throughout the season of navigation, such lights and other signals on said bridge as may be required by the Light-House Board for the security of navigation.

SEC. 7. That the bridge authorized to be constructed by this act shall be located and built under and subject to such regulations for the security of navigation on said river as the Secretary of War shall prescribe; and to secure that object said corporation shall submit for his examination a design and drawings of the bridge, piers, approaches, and accessory works, and a map of the location, giving, for a space of at least three miles above and one mile below the proposed location, the topography of the banks of the river and the shore-lines at high and low water. This map shall be accompanied by

others drawn on the scale of one inch to two hundred feet, giving, for a space of one-half a mile above the line of the proposed bridge and one-quarter of a mile below, an accurate representation of the bottom of the river, by contour lines five feet apart, determined by accurate soundings, and also showing over the whole width of this part of the river the force and direction of the currents at low water, at high water, and at least one intermediate stage by triangulated observations on suitable floats. The maps shall also show the location of other bridges in the vicinity, and shall give such information as the Secretary of War may require for a full and satisfactory understanding of the subject; and the construction of the proposed bridge shall not be commenced until the location and plans thereof are approved by the Secretary of War.

SEC. 8. That any bridge constructed under the authority of this act shall be built under the general supervision of the Secretary of War, and no changes or alterations in plans shall be made during the construction of said bridge or after its completion, unless said changes or alterations conform to the provisions of this act and are authorized by the Secretary of War. That such alterations and changes as may be required by the Secretary of War in said bridge so as to preserve free and convenient navigation shall be made under the direction of the Secretary of War at the expense of the company or persons owning, controlling, or operating said bridge. That during original construction or in carrying out any authorized changes or repairs of said bridge a navigable channel shall be preserved at the site of the bridge at all times, and the water-way of the river shall not be obstructed to a greater extent than is absolutely necessary, and such lights and buoys shall be kept on all coffer-dams, piles, and so forth, as may be necessary for the security of navigation.

SEC. 9. That whenever the Secretary of War has good reason to believe that any of the provisions of sections four, six, and eight of this act have not been complied with by the company or persons owning, controlling, or operating the bridge authorized under its provisions it shall be the duty of the Secretary of War, on satisfactory proof thereof, to require the said company or persons to comply with the provisions of said sections, and, on failure of said persons or company to comply with said requirements within a reasonable time, the Secretary of War shall proceed to cause the necessary work, in the form of additions, alterations, repairs, or removal of obstructions, to be made at the expense of the United States and shall refer the matter, without delay, to the Attorney-General of the United States, whose duty it shall be to institute, in the name of the United States, proceedings in the circuit court of the United States in and for the district in which any portion of said obstruction or bridge may be, for the recovery of such expense, and all moneys accruing from such proceedings shall be covered into the Treasury of the United States.

SEC. 10. That all railroad companies desiring the use of the bridge authorized by this act shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same, and over the approaches thereto, upon the payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies.

SEC. 11. That the bridge constructed, maintained, and operated under this act and according to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transportation over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation of said mails, troops, and munitions over the railroads and public highways leading to said bridge; and the United States shall have the right of way for postal telegraph and telephone purposes over said bridge.

SEC. 12. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date of approval thereof.

SEC. 13. That the right to alter, amend, or repeal this act is hereby expressly reserved; and the right to require the entire removal of the bridge constructed under the provisions of this act, at the expense of the owners thereof, whenever Congress shall decide that the public interests require it, is also expressly reserved.

Approved, October 1, 1890.

AN ACT to authorize the construction of a bridge across the Missouri River at some accessible point in Boone County, in the State of Missouri.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Chicago, Hannibal and Springfield Railroad Company, an incorporation organized under the laws of the State of Illinois, its assigns, or successors, is hereby authorized to construct and maintain a bridge across the Missouri River at such point as may be hereafter selected by said corporation between the towns of Providence and Rocheport, in the county of Boone, in the State of Missouri, as shall best promote the public convenience and welfare and the necessities of business and commerce, and also to construct accessory works to secure the best practical channel-way for navigation, and confine the flow of the water to a permanent channel at such point, and to lay on and over said bridge one or more railroad tracks for the more perfect connection of any railroads that are or shall be constructed to said river at or opposite said point.

SEC. 2. That said bridge shall be constructed and built without interference with the security and convenience of navigation of said river beyond what is necessary to carry into effect the rights and privileges hereby granted; and in order to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawing of the bridge and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the high and low water lines upon the banks of the river, the direction and strength of the currents at all stages of the water, with the soundings accurately showing the bed of the stream, and the location of any other bridge or bridges, such map to be sufficiently in detail to enable the Secretary of War to judge of the proper location of said bridge, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War, the bridge shall not be built: *Provided*, That the said bridge shall be made with unbroken and continuous spans, and shall have three or more channel-spans, and shall not be of less elevation at any point than fifty-five feet above high-water mark, as understood at the point of location, to the lowest part of the superstructure; nor shall the spans of said bridge be less than four hundred feet in length, and the piers of said bridge shall be parallel with the current of said river, and the main span shall be over the main channel of the river, and said company or corporation shall maintain at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe: *Provided, also*, That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the owners of said bridge and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

SEC. 3. That the Secretary of War is hereby authorized and directed, upon receiving such plan and map and other information, and upon being satisfied that a bridge built on such plan and with such accessory works and at such locality will conform to the prescribed conditions of this act, to notify the company that he approves the same; and upon receiving such notification the said company may proceed to an erection of said bridge, conforming strictly to the approved plan and location; and should any change be made in the plan of the bridge or said accessory works during the progress of the work thereon, such change shall be subject likewise to the approval of the Secretary of War, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the case may be brought in the circuit court of the United States of the district of the State of Missouri, in whose jurisdiction any portion of said obstruction or bridge may be located.

SEC. 4. That the said bridge and accessory works, when built and constructed under this act, and according to the terms and limitations thereof, shall be lawful structures; and said bridge shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge; and said bridge shall enjoy the rights and privileges of other post-routes in the United States.

SEC. 5. That the United States shall have the right of way across said bridge and approaches for such postal and telegraph lines as the Government may construct or control.

SEC. 6. That Congress shall have power at any time to alter, amend, or repeal this act, and all alterations of said bridge shall be made and all obstructions shall be re-

moved at the expense of the owners of or persons controlling such bridge: *Provided, further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

SEC. 7. That this act shall be void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date of the approval of this act.

Approved, October 1, 1890.

AN ACT authorizing the construction of a bridge across the Osage River at some accessible point in the county of Benton, in the State of Missouri.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Chicago, Hannibal and Springfield Railroad Company, an incorporation organized under the laws of the State of Illinois, its assigns or successors, is hereby authorized to construct and maintain a bridge across the Osage River at such point as may hereafter be selected by said corporation in the county of Benton, in the State of Missouri, as shall best promote the public convenience and welfare and the necessities of business and commerce, and also to construct accessory works to secure the best practicable channel-way for navigation, and to lay on and over said bridge one or more railroad tracks for the more perfect connection of any railroads that are or shall be constructed to said river at or opposite said point.

SEC. 2. That said bridge shall be constructed and built without interference with the security and convenience of navigation of said river; and in order to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge and a map of the location, giving for the space of one-half mile above and one-half mile below the proposed location the high and low water lines upon the banks of the river, the direction and strength of the currents at all stages of the water, with the soundings accurately showing the bed of the stream and the location of any other bridge or bridges, such map to be sufficiently in detail to enable the Secretary of War to judge of the proper location of said bridge, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be commenced or built: *Provided*, That if the said bridge shall be made with unbroken and continuous spans, they shall conform in length and height to the requirements of the Secretary of War: *And provided, also*, That if any bridge built under this act shall be constructed as a draw-bridge, the same shall be constructed as a pivot draw-bridge, with a draw over the main channel of the river at an accessible and navigable point, and with spans of such length as the Secretary of War shall prescribe, and the head-room under said bridge shall conform to the requirements of the Secretary of War: *Provided, also*, That said draw shall be opened promptly upon reasonable signal for the passing of boats; and said company or corporation shall maintain, at its own expense, from sunset till sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe: *Provided, also*, That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War, upon a hearing of the allegations and proofs of the parties.

SEC. 3. That the Secretary of War is hereby authorized and directed, upon receiving the plan and map and other information, and upon being satisfied that a bridge built on such plan and with such accessory works and at such locality will conform to the prescribed conditions of this act, to notify the company that he approves the same; and upon receiving such notification the said company may proceed to an erection of said bridge, conforming strictly to the approved plan and location; and should any change be made in the plan of the bridge or said accessory works during the progress of the work thereon, such change shall be subject likewise to the approval of the Secretary of War; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the case may be brought in the circuit court of the United States for the district for the State of Missouri, in whose jurisdiction any portion of said obstruction or bridge may be located. All changes in said bridge required at any time by the Secretary of War shall be made at the expense of the persons or corporation owning or controlling said bridge.

SEC. 4. That the said bridge and accessory works, when built and constructed under this act and according to the terms and limitations thereof, shall be lawful structures; and said bridge shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the rail-roads or public highways leading to said bridge; and said bridge shall enjoy the rights and privileges of other post-routes in the United States.

SEC. 5. That the United States shall have the right of way across said bridge and its approaches for such postal and telegraph lines as the Government may construct or control.

SEC. 6. That Congress shall have power at any time to alter, amend, or repeal this act, so as to prevent or remove all material and substantial obstructions to the navigation of said river by the construction of said bridge and its accessory works; and all alterations of said bridge shall be made and all such obstructions shall be removed at the expense of the owners of or persons controlling such bridge: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

SEC 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date hereof.

Approved, October 1, 1890.

AN ACT to authorize the construction of a bridge across the Missouri River at the most accessible point within one mile above or below the town of Quindaro, in the county of Wyandotte and State of Kansas.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Wyandotte County Bridge and Terminal Railway Company, a corporation duly created and existing under the laws of the State of Kansas, and its successors, be, and they are hereby, authorized to construct and maintain a bridge and approaches thereto over the Missouri River at the most accessible point, to be selected by it or them, within one mile above or below the town of Quindaro, in the county of Wyandotte and State of Kansas. Said bridge shall be constructed to provide for the passage of railway trains, and, at the option of said company, or its successors, said bridge may be so constructed or maintained that passage may be accorded to wagons and vehicles of all kinds, and for the transit of animals and for foot-passengers, under such reasonable rules and regulations as may be prescribed by said corporation, or its successors, and be approved from time to time by the Secretary of War.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States, or for passengers and freight passing over said bridge, than the rate per mile paid for the transportation over the railroad or public highways leading to the said bridge; and it shall enjoy the rights and privileges of other post-roads in the United States.

SEC. 3. That if said bridge shall be made with unbroken and continuous spans the spans thereof shall not be less than three hundred feet in length in the clear, and the main span shall be over the main channel of the river and not less than four hundred feet in length in the clear; the lowest part of the superstructure of said bridge shall be at least fifty feet above extreme high-water mark, as understood at the point of location, and the bridge shall be at right angles to, and its piers parallel with, the current of the river: *Provided*, That said company or corporation shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe. No bridge shall be erected or maintained under the authority of this act which shall at any time substantially or materially obstruct the free navigation of said river; and if any bridge erected under such authority shall, in the opinion of the Secretary of War, obstruct such navigation he is hereby authorized to cause such change or alteration of such bridge to be made as will effectually obviate such obstruction; and all such alterations shall be made and all such obstructions be removed at the expense of the owner or owners of said bridge; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the cause may be brought in the circuit courts of the United States in the States of Missouri or Kansas in whose jurisdiction any portion of said obstruction or bridge may be located: *Provided further*, That nothing in this act shall be construed as to repeal or modify any of the provisions of law now existing in ref-

erence to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

SEC. 4. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said persons or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built; and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War.

SEC. 5. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, the Secretary of War shall fix the same upon a hearing of the allegations and proofs of the parties.

SEC. 6. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in said structure, or its entire removal, at the expense of the owners thereof, whenever Congress shall decide that the public interest requires it, is also expressly reserved.

SEC. 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date hereof.

Approved, October 1, 1890.

AN ACT to promote the administration of justice in the Army.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That hereafter in time of peace all enlisted men charged with offenses now cognizable by a garrison or regimental court-martial shall, within twenty-four hours from the time of their arrest, be brought before a summary court, which shall consist of the line officers second in rank at the post or station or of the command of the alleged offender, and at stations where only officers of the staff are on duty the officers second in rank shall constitute such court, who shall have power to administer oaths and to hear and determine the case, and when satisfied of the guilt of the accused party adjudge the punishment to be inflicted. There shall be a summary court record-book or docket kept at each military post, and in the field at the headquarters of the command, in which shall be entered a record of all cases heard and determined and the action had thereon, and no sentence adjudged by said summary court shall be executed until it shall have been approved by the post or other commander: *Provided*, That when but one commissioned officer is present with a command he shall hear and finally determine such cases as require summary action: *Provided further*, That the President be, and he hereby is, authorized to prescribe specific penalties for such minor offenses as are now brought before garrison and regimental courts-martial: *Provided, further*, That any enlisted man charged with an offense and brought before such summary court may, if he so desires, object to a hearing and determination of his case by such court and request a trial by court-martial, which request shall be granted as of right, and when the court is the accuser the case shall be heard and determined by the post-commander, or by regimental or garrison court-martial: *And provided further*, That post and other commanders shall, on the last day of each month, make a report to the department headquarters of the number of cases determined by summary court during the month, setting forth the offenses committed and the penalties awarded, which reports shall be filed in the office of the judge-advocate of the department.

SEC. 2. That it shall be lawful for any civil officer having authority under the laws of the United States or of any State, Territory, or District, to arrest offenders, to summarily arrest a deserter from the military service of the United States and deliver him into the custody of the military authority of the General Government.

Approved, October 1, 1890.

AN ACT to authorize the construction of a bridge across the Altamaha River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assemb'ed, That the assent of the United States of America is hereby given to the Brunswick, Athens and Northwestern Railroad Company, a corporation incorporated by the laws of the State of Georgia, its successors and assigns, and such other persons as may be associated with it, to construct and maintain a bridge over the Altamaha River at a point by it to be selected at ar near Oglethorpe Bluff.

SEC. 2. That the bridge shall be so constructed by draw-span or otherwise that a free and unobstructed passage may be secured to all vessels and other water craft navigating said river; that any bridge constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company shall submit to the Secretary of War, for his examination and approval, the design and drawings of the bridge, piers, and approaches, and a map of the location, giving, for the space of at least one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines at high water and at low water, and the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, and the location of any other bridge or bridges, wharves, landings, or ferries, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built; and after such approval by the Secretary of War the approved plans and designs for the bridge shall not be deviated from or added to either during the construction or after the completion of the bridge until the proposed change shall have been submitted to the Secretary of War and received his approval; and the said bridge shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said bridge; and if said bridge be built with a draw said draw shall be opened promptly upon reasonable signal for the passage of boats or other craft; and the said company or corporation shall maintain at its own expense, from sunset until sunrise, such lights or other signals on said bridge as the Light House Board shall prescribe; and if at any time the navigation of said river shall in any manner be obstructed or impaired by the bridge authorized by this act to be constructed, the Secretary of War shall have authority, and it shall be his duty, to require said company to alter and change said bridge at its own expense, in such manner as may be proper to secure free and complete navigation without impediment; and if upon reasonable notice to said company, its successors or assigns, to make such change or improvements, the said company fails to do so, The Secretary of War shall have authority to make the same, and all the rights conferred by this act shall be forfeited upon said failure, and Congress shall have the power to do any and all things necessary to secure the free navigation of said river: *Provided, also*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operations of the same.

SEC. 3. That any bridge built under this act and subject to its limitations shall be a lawful structure and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same and its approaches of the mails, the troops, and munitions of war of the United States, or passengers or freight than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge, and it shall enjoy the rights and privileges of other post-roads of the United States; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies, and the United States shall have the right of way across said bridge and its approaches for said postal telegraph purposes.

SEC. 4. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in said structure, or its removal, at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest requires it, is also expressly reserved.

SEC. 5. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years and completed within four years from the date hereof.

Approved, October 1, 1890.

JOINT RESOLUTION for removing damages caused by floods in Sacramento and Feather rivers.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the balances unexpended of the appropriations for improving Sacramento and Feather rivers, California, acts of August second, eighteen hundred and eighty-two, July fifth, eighteen hundred and eighty-four, August fifth, eighteen hundred and

eighty-six; and August eleventh, eighteen hundred and eighty-eight, not exceeding one hundred and ten thousand four hundred and forty-nine dollars and sixty seven cents, in all, are hereby made immediately available for expenditure in improving navigation by repairing the damages caused by floods in the Sacramento and Feather rivers, subject only to the restrictions contained in Sec. 3., of the River and Harbor act which became a law August eleventh, eighteen hundred and eighty-eight.

Approved, December 21, 1889.

JOINT RESOLUTION for the removal of obstructions to navigation in the Missouri River and extension of jetty work at the mouth of Columbia River, Oregon.

Whereas the amounts appropriated by Congress in the act of eighteen hundred and eighty-eight, for the improvement of rivers and harbors, for the removal of snags and other obstructions from the Missouri River and the Columbia River, to be expended under the control of the Missouri River Commission, and of the Chief of Engineers of the War Department, have been in each case exhausted, and there being no funds remaining available, for the purposes aforesaid, and

Whereas, it is important to the navigation of said rivers, that certain snags and obstructions be removed at once, to the end that navigation may not be suspended by reason of said obstructions, therefore

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the sum of seventy-five thousand dollars, or so much thereof as may be necessary, is hereby appropriated out of any money in the Treasury, not otherwise appropriated, which shall be expended under the supervision and direction of the Missouri River Commission, in the removal of snags and other obstructions to the navigation of said river, between St. Joseph, Missouri, and the mouth of said river; and the like sum of seventy-five thousand dollars is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to be expended under the supervision and direction of the Secretary of War, for continuation of the jetty work at the mouth of the Columbia River in Oregon, said work to be commenced as soon as the rivers aforesaid, and their freedom from ice will permit, and to be continued until completed, and said sum of one hundred and fifty thousand dollars is hereby made immediately available for the purposes aforesaid.

Approved, February 22, 1890.

JOINT RESOLUTION for the relief of sufferers in the Mississippi Valley.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the President of the Mississippi River Commission be, and is hereby authorized, out of money heretofore appropriated for the improvement of the Mississippi River, to purchase or hire such boats as may be immediately necessary to rescue inhabitants in the overflowed districts of the Mississippi River Valley, and to use said boats for the purpose named.

Approved, April 3, 1890.

JOINT RESOLUTION requesting the Secretary of War to cause a further report to be made as to the practicability and approximate cost of tunneling the Detroit River at or near Detroit, Michigan.

Whereas, there having been commissions of Army engineers appointed in the years eighteen hundred and seventy-three, eighteen hundred and seventy-nine, and eighteen hundred and eighty-nine to investigate and report upon the necessity and practicability of the proper means of crossing the Detroit River at or near Detroit, Michigan, by bridge or otherwise; and

Whereas, said commissioners have limited such investigations more particularly to the question of bridging said river: Therefore,

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War is hereby directed to have the said Board of Engineers appointed by the Secretary of War in eighteen hundred and eighty-nine to more fully report upon (at the earliest time practicable) the advisability, practicability, and approximate cost of tunneling the Detroit River at or near Detroit, Michigan, in such a manner as to accommodate the large trade and commerce crossing the river at that point, without permanent obstruction of any kind whatever to the navigation interests of said river, with a view to the passage of said commerce through said tunnel from the United States into and through the Dominion of Canada and return; such re-

port to be based upon the examination already made by said Board, or, if necessary to a compliance with this resolution, to make such report after further inquiry into the subject.

Approved, April 19, 1890.

JOINT RESOLUTION Authorizing the Secretary of War to use rations for the relief of destitute persons in the district overflowed by the Mississippi River and its tributaries, and making an appropriation to relieve the sufferers by said overflow.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the sum of one hundred and fifty thousand dollars is hereby appropriated, out of any money in the Treasury not otherwise appropriated to be expended by and under the direction of the Secretary of War, in the purchase and distribution of subsistence stores to such destitute persons as may require assistance in the district overflowed by the Mississippi River and its tributaries, by the recent floods. And the Secretary of War is authorized to use the steamers and other boats and vessels belonging to or now employed by the Government upon the Mississippi River and its tributaries in the transportation and distribution of the supplies furnished by the United States or individuals, to and among said destitute and suffering people, and he may employ such other means of transportation as he may deem necessary to carry the purpose of this Joint Resolution into effect.

Approved, April 25, 1890.

JOINT RESOLUTION authorizing the use and improvement of Castle Island, in Boston Harbor

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That permission be, and is hereby, granted to the city of Boston, in the State of Massachusetts, through its park commissioners, to improve and beautify Castle Island, situated in said city, and belonging to the United States, in connection with a public park to be laid out on land adjoining and connecting with said island, with the right to said city of Boston to make such excavations and fillings and erect and maintain such structures as the Secretary of War may, from time to time, approve: *Provided*, That this resolution shall not be construed to pass any title in said island, but that the ownership and control of the said grounds shall remain entirely in the United States, and shall be subject to such changes and uses for military or other purposes as the Secretary of War may direct, and that the bridge leading from the harbor line to the island shall not be constructed until the plans for the same have been approved by the Secretary of War.

Approved, May 1, 1890.

JOINT RESOLUTION to continue in force an act authorizing the construction of a bridge over Bayou Bernard, in the State of Mississippi.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the act entitled "An act to authorize the construction of a bridge over Bayou Bernard, in the State of Mississippi," approved February twenty-third, eighteen hundred and eighty-seven, be, and the same is hereby, revived and continued in force and effect; and that the time for the completion of the bridge therein provided for be extended three years from February twenty-third, eighteen hundred and ninety, and that said act be so revived and extended, with all its provisions in full force the same as though the time in the original bill for the completion of said bridge had been six years instead of three years.

Approved, May 14, 1890.

JOINT RESOLUTION authorizing the use and improvement at Fort Sewall at Marblehead, Massachusetts.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That permission be, and is hereby, granted to the town of Marblehead, in the State of Massachusetts, to improve and beautify Fort Sewall and its appurtenant lands and grounds, situated in said town, and belonging to the United States, with the right to said town to make such excavations and fillings and erect and maintain such structures as the Secretary of War may from time to time approve: *Provided*, That this resolution shall not be construed to pass any title in said fort lands or grounds, but that the own-

ership and control of the said grounds shall remain entirely in the United States, and shall be subject to such changes and uses for military or other purposes as the Secretary of War may direct.

Approved, May 19, 1890.

JOINT RESOLUTION extending the privilege of the Library of Congress to the members and Secretary of the Interstate Commerce Commission, and the Chief of Engineers of the Corps of Engineers United States Army.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Joint Committee of Congress on the Library be authorized to extend the use of the books in the Library of Congress to the members and secretary of the Interstate Commerce Commission, and the Chief of Engineers of the Corps of Engineers United States Army, resident in Washington, on the same conditions and restrictions as members of Congress are allowed to use the Library.

Approved, August 28, 1890.

JOINT RESOLUTION appropriating money to the Territory of Oklahoma to relieve destitution therein.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the unexpended balance of an appropriation made by public resolution numbered fifteen, approved April twenty-fifth, eighteen hundred and ninety, for the relief of persons in the district overflowed by the Mississippi River and its tributaries, be, and the same is hereby, re-appropriated to the Territory of Oklahoma, to be expended as the law of said Territory, enacted for the purpose, may direct for the relief of citizens of that Territory who have been rendered destitute by the unexampled drought of the present season.

Approved, September 1, 1890.

JOINT RESOLUTION granting permission to officers and enlisted men of the Army and Navy of the United States to wear the badges adopted by military societies of men who served in the war of the revolution, the war of eighteen hundred and twelve, the Mexican war, and the war of the rebellion.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the distinctive badges adopted by military societies of men who served in the armies and navies of the United States in the war of the Revolution, the war of eighteen hundred and twelve, the Mexican war, and the war of the rebellion respectively, may be worn upon all occasions of ceremony by officers and enlisted men of the Army and Navy of the United States, who are members of said organizations in their own right.

Approved, September 25, 1890.

JOINT RESOLUTION to correct an error in the act entitled "An act making appropriations for the construction, repair and preservation of certain public works on rivers and harbors, and for other purposes," approved, September nineteenth, eighteen hundred and ninety.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That section one of the act entitled "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved September nineteenth, eighteen hundred and ninety, be, and the same is hereby, amended so that the clause making appropriation for the improvement of Illinois River, Illinois, shall read, "Improving Illinois River, Illinois: Continuing improvement, two hundred thousand dollars."

Approved, September 29, 1890.

JOINT RESOLUTION to permit the Secretary of War to grant a revocable license to use a pier, as petitioned by vessel owners of Chicago, Illinois.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War is hereby authorized to grant by revocable license the use of the United States pier at Chicago, Illinois, situated North and East of the Illinois Central Railroad Company's wharf number one, and on south side of

Chicago River; to such party or parties as he may deem wise and expedient, subject to the following conditions:

First. Said party or parties shall keep in thorough repair that part of the pier, two hundred and twenty-five feet in length, projecting beyond the end of the Illinois Central Railroad Company's docks so called.

Second. That the said party or parties, at his or their own expense, shall rebuild and keep in repair the superstructure of said one thousand feet of pier during the continuance of the license.

Third. That the United States Government shall have free use of any necessary part thereof for storage, upon giving the said party or parties sufficient notice to clear such part of said pier for such uses by the United States.

Fourth. That the said party or parties shall keep that part of the entrance to the Chicago River within fifty feet of the pier dredged, and shall prevent the dumping of ashes or refuse from vessels landing at the pier into the entrance to Chicago Harbor.

Approved, October 1, 1890.

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